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CAN FEDERAL PROCUREMENT PRACTICES BE USED TO REDUCE SOLID WASTE

Arthur D. Little, Incorporated

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CAN FEDERAL PROCUREMENT PRACTICES BE USED TO REDUCE SOLID WASTE?

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16. ABSTRACT

The research discusses the possibilities for revising Federal Government procurement specifications to provide incentives for reducing solid waste. The extent of Federal direct purchases relative to domestic use was a primary consideration in the selection criteria. Disposal problems and the technical feasibility of including recycled materials in procurement specifications were also considered. The opportunity areas selected for in-depth evaluation were paper and paperboard, metals, glass, and rubber. Alternative scenarios were developed to assess the impacts of changing specifications for linerboard. The report concludes that changing government specifications for paper products, especially those used in packaging, offered the best opportunity for solid waste reduction.

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FOREWORD

Man and his environment must be protected from the adverse effects of pesticides, radiation, noise and other forms of pollution, and the unwise management of solid waste. Efforts to protect the environment require a focus that recognizes the interplay between the components of our physical environment--air, water, and land. The National Environmental Research Centers provide this multidisciplinary focus through programs engaged in

- studies on the effects of environmental contaminants on man and the biosphere, and
- a search for ways to prevent contamination and to recycle valuable resources.

As part of these activities, this study examines those areas in which the Federal Government's procurement power could be utilized most effectively as an economic incentive to encourage the reduction of solid waste and increase the use of recycled materials.

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Research Center, Cincinnati

ABSTRACT

Although the Federal Government is the largest single buyer in the United States, it purchases only a small percentage of the domestic output of most commercial products. For example, only about one percent of all paper and paperboard products is purchased directly by the Government for its own use. In most instances, however, the purchase of these products can have a greater impact on the economy than these small percentages suggest, because of the multiplier or "ripple" effect. Thus, when the General Services Administration (GSA) recently modified its specifications for selected paper products to include reclaimed fiber or waste paper, New York City and some of the state governments followed the GSA's lead. Segments of the private sector, including some of the largest U.S. companies, also followed.

In this study we recognized that this "ripple" effect exists and also recognized certain conditions that tend to promote it; however, we were unable to quantify the "ripple" effect. Nevertheless, even on a qualitative basis the "ripple" effect was an essential criterion in the selection of those product specifications among the more than 50,000 that should be modified to effectively promote recycling and/or reduce the generation of solid waste.

On the basis of our analysis of all product categories, modifying Government specifications for packaging materials and systems will have the greatest impact on reducing solid waste. The Government uses 6 to 10 percent of all packaging in the United States (based on value), according to estimates made by some Government agencies. The Government buys packaging indirectly when it buys most products, and the Government also purchases packaging materials directly, such as corrugated shipping cases and metal drums, for various shipping applications. Because packaging is a very "visible" purchase, and because it is widely used in the economy, potentially, then, the "ripple" effect of this purchase can be very great.

Packaging uses many materials, but one of the major ones is paper. And packaging also accounts for about 50 percent of all sales of paper products in the United States. Consequently, paper products--especially those used for packaging--are another group of products whose specifications can be changed to significantly reduce the generation of solid waste. Few of the other material categories are as attractive as the paper category as an opportunity for reducing solid wastes by using the leverage of Federal purchasing.

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FINDINGS AND RECOMMENDATIONS

Many of the recommendations below are only tentative and are based on certain assumptions with regard to the technology and economics of manufacture. Because our economy is based primarily on the use of virgin material to manufacture the wide range of products available to us, industry, for the most part, has been unaware of the effect of incorporating recycled material on the performance of its products. Consequently, changes in Government product specifications must be introduced with caution and only after appropriate study.

GENERAL RECOMMENDATIONS

1. Generally, if secondary material is incorporated into a product, or the weight of the product is reduced, one must consider the effects of this action on: (a) the physical properties of the product, (b) the ability to fabricate the product, and (c) the subsequent performance of the product. This area warrants research sponsored by both Government and industry. The ultimate objective of this research should be to prepare product specifications that detail the necessary performance requirements rather than specify particular raw materials.

2. Some new secondary products, which represent new applications for waste materials, are being developed and evaluated. The Federal Government should follow these programs closely and, if warranted, support them financially. As these products become technically and economically viable, the Federal Government should write specifications for them and purchase them. This action should have a substantial "ripple" effect on the purchasing policy of local and state governments.

3. In this study we concentrated on the direct purchases of the Federal Government where the Government itself is the consumer. However, the Government also provides funds via grants, etc., to state and local governments and to certain private enterprises. In these cases, the Federal Government sets guidelines and specifications for the products although it is not the consumer. These purchases are considered indirect purchasing. We believe the Government should study the modification of these purchase specifications as a separate undertaking, because this approach could be a very effective way of reducing the generation of solid waste.

PAPER

1. Of the three major markets for paper and paperboard--packaging, cultural papers, and personal papers--packaging represents the best solid waste reduction opportunity area, because Government purchases in this market could have a very significant "ripple" effect.

2. Another important paper product area where changes in Federal specifications can effectively reduce solid wastes is in construction. If the developing technology and economics of processing mixed papers from municipal trash to structural materials prove satisfactory, new Federal specifications should be introduced to encourage the use of these new materials.

3. Because the paper industry is made up of a number of sub-industries with widely varying characteristics, the effectiveness of changing Government purchasing practices to increase recycling should be studied individually for each sub-industry before recommendations are made. Complete analysis of all paper products was beyond the scope of this study; therefore, we analyzed only linerboard.

4. In making recommendations for linerboard specifications, we assumed the following:

- It is possible to duplicate the strength properties of the virgin Kraft linerboard by using 100 percent secondary fiber and chemical additives.
- The cost of these chemicals and processing treatment will still allow the secondary fiber linerboard to compete on a basis with the virgin product.
- It is necessary that the secondary fiber linerboard have the same strength as the virgin Kraft board.
- The price of used corrugated cases that provide the secondary fiber for the board will not increase significantly with greater demand.

If these assumptions prove to be correct, we recommend that the Government require linerboard producers to certify that they use, on the average, "X" percent secondary fiber* in their total linerboard production, if they wish to bid on a Government purchase. The Government should change the specifications gradually, consistent with the demand and growth for linerboard and the opportunities for installing secondary fiber linerboard facilities. Based on our model analysis, we recommend specifying the secondary fiber level at 5 percent in 1975 and increasing it about 3 percent every 3 years to a total of about 15 percent by 1985.

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*Secondary fiber is fiber that has been used more than once in papermaking, and it includes only converter and post-consumer waste.

METAL

1. Many items are purchased in commercial packaging, where the container is not specified. To decrease the quantity of significant wastes from packaging, the Federal Government should specify that beverages, which it now purchases in cans, should be packaged in cans that are both tin-free and lead-free (all-aluminum, all tin-free steel, and tin-free steel cans with easy-open aluminum closures). As food items become available in similar cans, such containers should also be specified; and, as easy-open, tin-free steel tops become available as replacements for the easy-open aluminum tops, they should be specified.

2. These recommendations for packaging fabricated from one metal will improve the recyclability of these containers by improving the homogeneity of metal can wastes. However, this approach is meaningful only if systems are available for their separation and, more importantly, if a market exists for such scrap. Therefore, the Government should support research to develop new products such as construction-grade steel and aluminum based on post-consumer or obsolete metal scrap, especially that derived from municipal wastes. This research is of prime importance, because it can open up new markets for metal scrap; otherwise, any specifications designed to promote recyclability such as those cited above will be ineffective. The most attractive secondary products are long-service-life construction materials such as pipe, tile, and wall panels. The market for these products also can be affected by indirect Federal purchasing.

GLASS

1. For those products now purchased in glass containers, the Government should specify the lightest containers commercially available that meet the necessary performance requirements. For example, the new lighter containers which are strengthened by a chemical surface treatment, or by the use of a glass-organic composite, should be specified as they become

available. To provide an impetus for a "ripple" effect, the introduction of this specification should be publicized. Industry should be made aware that the Government is prepared to introduce this type of specification as soon as a packager uses the preferred container for his product.

RUBBER

1. The Government should specify radial tires as original equipment in their purchase of passenger cars, and they should specify and purchase radials as passenger car replacement tires, wherever possible.

2. The Government should specify that tire manufacturers who bid for tire contracts with the Government should certify that 10 percent of the rubber used in their total tire production is reclaim. The concentration of reclaim should be adjusted upward or downward each bidding period, depending upon the response of the bidders.

3. We recommend that the Government initiate a program to adequately test retreaded vs. original equipment (OE) tires, to ensure that they are safe when subjected to the same driving conditions as OE tires. The retreaded tires used in the test should be processed according to the recommended standards of the Tire Retreading Institute. If the results of the recommended test are positive, they should be publicized widely. This publicity can go a long way toward promoting the use of retreaded tires beyond the Government sector.

4. The Government and industry should continue their research to develop appropriate non-destructive tests to measure the adequacy of discarded tire casings for retreading.

5. If the road tests confirm the safety of retreads, we recommend that the Federal Specification for retreated tires (ZZ-T-00441C) be modified to remove the requirement that these tires must pass the Department of Transportation (DOT) Motor Vehicle Safety Standard MV SS117 (National Traffic and Motor Vehicle Safety Act of 1966). According to the retreaders, the DOT standard does not reflect actual tire performance, and many of the retreaded tires cannot qualify, even though the retreaders believe them to be safe and are willing to provide warranties. In place of the wheel tests required under this standard, the specification should incorporate the processing standards of the Tire Retreading Institute.* If a satisfactory casing inspection test is developed, this test also should be required.

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*Since the work under this study was completed, a Federal court has ruled that the wheel test is no longer required.

6. We recommend that Government and industry undertake a research program to define the most effective way of utilizing used or reclaimed rubber as a road-building material. The Government could then specify used or reclaimed rubber as an aggregate or as a new surfacing material for the roads built by Federal and local government, if the research study can adequately define the product.

PLASTICS

1. We recommend that the Government take steps to remove the restriction on non-virgin materials in the specifications for plastic, corrugated drainage tubing. Instead, specifications based on performance should be developed. In addition, adequate test methods and statistical sampling procedures should be specified to assure no decrease in product quality.

This recommendation also depends upon the availability of the raw material--high density polyethylene scrap. In the waste stream, this source is available in the form of plastic bottles, but today no mechanism exists for recovering these bottles economically.

2. We recommend that the REA specification for polyethylene used in wire and cable be rewritten to allow the use of in-house-generated scrap for use at levels of 2 to 5 percent with virgin resin for the manufacture of the outer jacket. This revision should be reviewed by selected manufacturers and the Technical Standards Committee.

PACKAGING

1. Because of budgetary constraints, we focused on one aspect of the packaging system--the delivery of subsistence items to Government personnel. However, we believe that packaging is the best solid waste reduction opportunity area and, therefore, recommend an in-depth study to determine the many ways that Federal purchasing policy can be used to increase recycling and reduce the generation of solid waste.

2. Larger packages should be employed for central commissary operations, both for operational economies and to reduce the quantities of packaging materials entering the solid waste stream. Very large packages, i.e., over 50-60 pounds, would require the installation of mechanical handling equipment within many kitchen operations, because they cannot be handled manually.

3. The Government should specify waxed or otherwise lined corrugated cases for shipment of fresh fruits and vegetables. With well-trained buyers, the amount of wooden cases, dunnage, packing pieces, etc., now used for the many different varieties of fruit and vegetable packaging could be reduced significantly. A concerted effort to unify packaging specifications for fresh produce away from "available" and towards uniformity and in the form and pack specified would reduce packaging waste and also improve the quality of produce purchased by the Government.

4. The use of bag-in-box for semibulk packaging of frozen concentrated juices is already commercially feasible and should be implemented for commissary or central kitchen installations.

5. We recommend that the Government foster an intensive research program to couple HTST (high temperature-short time) processing and aseptic packaging to allow for altering purchasing specifications away from the present No. 10 can for packaging low-acid foods such as soups, meats, and vegetables. Analogous programs could be carried out with high-sugar fluids such as jams and jellies. Successful completion of such studies would allow for the use of plastic pouches, and 5-10 gallon pails fabricated from polyethylene, steel, etc.

6. Packaging specifications should be reviewed and modified to include functional or use factors. This will allow the processor/packager to experiment and deviate, if the user is satisfied, and thereby direct the packager towards more desirable packaging systems that reduce solid waste.

7. Once new packaging is developed, the Government should petition the carriers (railroads, trucks, etc.) to modify their regulations, such as Rule 41. This rule has acted as a serious constraint in the development of modified packaging to reduce the generation of solid waste. Modification of this rule could have a very significant effect on all packaging used in the United States.

INTRODUCTION

A major challenge of the 70's is to reduce the volume of waste generated in our cities. Someone has calculated that every minute of the day 500,000 pounds of trash are dumped into garbage cans in this country. A major portion of the trash consists of disposable items such as packaging, old newspapers, and other paper goods. Most of the major cities are confronted with mountains of solid wastes, and disposal sites are gradually becoming less available. Under these approaching crisis conditions, the Federal Government enacted the Resource Recovery Act of 1970 (Public Law 91-512). Section 205 of this act requests a study of the "use of Federal procurement to develop market demands for recovered resources." Furthermore, the President, in 1971, requested the General Services Administration (GSA) to change its procurement specifications to require that paper purchased by the Federal Government contain a specified minimum percentage of recycled material.

To fulfill the requirements of the Resource Recovery Act and to obtain information for interested members of Congress, industry, the procurement agencies, and the public at large, the Environmental Protection Agency (EPA) authorized this study in 1971 to determine those areas in which the Federal Government's procurement power could be utilized most effectively as an economic incentive to encourage the reduction of solid waste and increase the use of recycled materials.

Our approach to this study of Government purchasing practices has been primarily through an analysis of Federal Government purchasing specifications to determine where current specifications might be changed to remove unnecessary restrictions against the use of secondary materials without reducing the necessary product performance requirements. Although specifications are based on technical needs, any changes can have an economic impact on the procuring agencies, the producing industries, and the secondary materials industries; in this study, therefore, these impacts have been considered in depth in the case of paper and only partially in the case of other materials. The major emphasis has been on the specifications used by the GSA, the Defense Supply Agency (DSA), and the Government Printing Office (GPO).

I. FEDERAL PROCUREMENT PRACTICES AND APPROACH TO STUDY

In 1971, the Federal Government purchased over $60.6 billion of services and goods. Of this amount, $46.7 billion was for defense purposes. As shown in the Appendix (Table A-1), the total expenditures for goods alone were $46.5 billion--$36.9 billion for defense items and $9.6 billion for non-defense. These statistics were derived from the Arthur D. Little, Inc., input/output forecasting model of the United States economy. Note that the products in Table A-1 include finished as well as intermediate goods. According to the National Commission on Government Procurement,[1] the Government contracted to spend $57.5 billion for goods and services in fiscal 1972. Thus, there is good agreement between these two estimates. These expenditures represent about one-fourth of the United States budget.

These funds are used to purchase more than 4.5 million items, according to the Defense Logistics Service Center of DSA. All of these items are described in the Federal Supply Catalogue and each item bears a Federal Stock Number (FSN). The Center, today, lists over 8 million reference numbers, which represent those items currently or previously in the system. The DSA itself centrally procures and manages about 1.8 million items.

SPECIFICATIONS AND STANDARDS

Because the Federal Government is the world's largest buyer of materials, it has to insure that what is purchased is suitable for the intended use. To meet this objective and obtain maximum value for every dollar spent, the requirements are expressed in the form of specifications and standards. Specifications are clear and accurate descriptions of the technical requirements for materials, products, or services. They specify the minimum requirements for quality and construction of materials and equipment necessary for an acceptable product. In general, specifications are in the form of written descriptions, drawings, prints, commercial designations, industry standards, and other descriptive references. Specifications are an integral part of the purchase contract.

Specifications

Government specifications usually are divided into six sections. The first deals with the scope and classification of the product, and the second cites related specifications and standards. The third section lists the requirements that must be met by the product. This is the key section, which outlines the necessary material and performance qualifications. Many Government specifications are primarily "material specifications;" i.e., they stipulate the use of certain materials to meet the necessary performance requirements. Others cite only performance requirements and do not specify materials. These "performance specifications" are thus the least restrictive with respect to materials. Some of the material specifications, on the other hand, are very restrictive and specify, for example, that only virgin material can be used.

The fourth section of the specification provides details about the various tests and inspections that must be carried out to insure the quality of the product, and the fifth section is concerned with preparation for delivery. This section, then, is very significant in terms of solid waste generation, because it describes the required packaging. The Government uses three packaging levels. A is the most stringent and is required when the product either is shipped overseas or must be stored for long periods in various environments. Level B is an intermediate level of packaging, which is demanded for most continental shipping and storage. In general, if the product is handled by the Government more frequently than it is handled in a typical commercial distribution channel, B packaging is required. Level C packaging is off-the-shelf packaging that is in accordance with commercial practice. This level is usually requested when the product is not stored for any length of time.

The sixth section of the specification is a compilation of miscellaneous requirements and notes; e.g., how to order various procurement documents and additional requirements for testing. Occasionally, as a means of expediting contract awards and deliveries of certain products, manufacturers are required to have their products pretested. This pretesting is required, for example, with the automobile tire. Once the product has been pretested, either by a Government or by a designated independent laboratory, and the product meets the specific requirements of the Government specification, the product is placed on a qualified products list (QPL). Only about 10 percent of the Government specifications contain such qualification requirements.

There are two distinct series of specification documents--Federal and military. Documents in the Federal series are developed for materials, products, or services used by at least one of the civilian agencies, in addition to one or more of the military services. These specifications are promulgated by the GSA and, if applicable, are mandatory for use by all Federal agencies including the Department of Defense.

Documents in the military series are developed for materials, products, or services used primarily by the military services. They also may be used by other Federal agencies. The military series provides for issuance of either coordinated military documents, which cover items or services required by more than one military department, or limited coordination military documents, which cover items or services of interest to only one military department, or to meet their immediate need where the agency does not allow time for coordination.

Standards

As noted above, specifications often reference other Federal and industry standards. These standards establish engineering or technical limitations and applications for materials, processes, methods, and designs. Standards generally include related criteria considered essential to achieve the highest practical degree of uniformity in materials and products or interchangeability of parts used in those products. A typical standard specifies and compiles for easy reference methods of testing which are applicable to a given product. Another type of Federal standard is used to reduce the number of sizes, colors, varieties, and types of materials and commodities to a minimum consistent with the needs of the Government.

Government specifications often cite industry standards. For example, GSA reported that industry standards are referenced more than 4000 times in various Federal specifications. More than 13,000 national standards are used in the U.S.A.[2] The most often cited industry standards are those developed by the American Society for Testing and Materials (ASTM). This organization develops standards and specifications through the cooperation of industry, government, and concerned individuals.

Preparation of Specifications

Federal specifications are developed through the cooperation of Federal agencies and representative segments of industry. When a particular Federal agency has specialized technical competence and available facilities, GSA assigns the development of specific projects to that agency. GSA, however, is responsible for the final acceptance and publication of the specifications. In the case of military specifications, the Assistant Secretary of Defense (Installations and Logistics) assigns standardization and purchasing management responsibilities to the military departments and defense agencies in coordination with GSA.

Inasmuch as the military departments are responsible for the technical characteristics of the items they use, most of the specifications required for procurement are assigned to them for preparation and maintenance. Specification preparation projects are assigned on the basis of interest and technical capability. The Defense Supply Agency (DSA) itself prepares specifications for medical, woodworking and metalworking machinery, and electronic parts.

In addition to the military and Federal specifications, there are special departmental specifications. These are prepared by individual government departments, agencies, or bureaus, in those instances where no existing Federal or military specification satisfies their specific need. An existing specification is often used as the basic description for the desired product, but modifications or variations are introduced to take care of essential differences. In certain Federal agencies, departmental specifications play an important role because of large-volume purchases of items peculiar to their own needs. Such agencies include the Federal Aviation Administration, Veterans Administration, Post Office Department, Tennessee Valley Authority, and the Department of the Interior. But, in general, most agencies have little need to develop their own specifications, because the majority of their open-market purchases are covered by existing ones.

The promulgation and use of specifications have proliferated, until today about 5,000 Federal and interim Federal specifications have been developed and issued by GSA, and about 40,000 specifications are listed by the military. In addition to these, perhaps between 15,000 and 20,000 specifications are listed by other agencies of the Government, according to a spokesman for the GSA.

In all cases, industry plays an important role in the preparation of government specifications. During their preparation, every specification is coordinated fully with a representative cross section of the industry concerned. Typically, the preparation of a Federal specification for a commercial product begins with a company's commercial specification. Very often, if the commercial specification meets the Government's needs, it will be adopted without modification. However, before the specification is adopted, the Government circulates the proposed specification to other firms for comment. Comments on the proposed specifications are usually requested not only from individual manufacturers but from technical societies and trade associations. In this way, the Government insures that Government specifications reflect the latest developments of modern technology and set forth requirements which are normally satisfied by the regular commercial production of the industries involved. Some of the more complex specifications require meeting with representatives of Federal agencies and industry in order to reach a consensus regarding the technical requirements of the specification. In addition, there are day-to-day contacts with suppliers, who aid in the development and revision of specifications.

Federal specification projects are initiated when the procurement need arises and when existing specifications have become obsolete, because of technical advances, or when revision is required for other reasons. Each Federal and military specification is programmed for review every five years as a minimum.

Interagency Support

Overall, assignment of agency managers for the various products purchased by the Government is coordinated through the Department of Defense Coordinated Procurement Program.[3] These assignments are shown in Table A-2. Assignments are made according to Federal Supply Class (FSC) numbers. The FSC number is a commodity classification designed to serve the function of supply and is sufficiently comprehensive in scope to permit the classification of all items purchased by the Government. As presently established, the FSC Classification System consists of 76 groups of commodities which are subdivided into 590 classes. Each class covers a relatively homogeneous area of commodities. The FSC code utilizes a 4-digit coding structure. The first two digits of the code number identify the group, and the last two digits identify the classes within each group. The FSC system is further used to develop the Federal Stock Number (FSN) mentioned above. The FSN for an item of supply includes the appropriate 4-digit FSC code number plus other digits.

Both the GSA and the DSA have prime responsibility for promoting interagency purchasing. These agencies purchase products for other agencies of the Government. In 1949, with the establishment of the GSA, a National Supply System was developed. The system now consists of the coordinated logistics activity of the Federal Supply Service (FSS) of GSA, the DSA, and other Federal agencies.

FSS procures personal property for both Federal and military agencies. And, to make thousands of common-use items readily available to Government agencies, FSS maintains depots and self-service stores. Storage depots are located in 10 FSS regions, and self-service stores are located in various cities that issue administrative supplies through a charge account system. The supplies provided by the depots are mandatory for use by Federal agencies. In some instances, FSS relegates responsibility for interagency support to other agencies. For example, the Veterans Administration, as the largest civilian user of non-perishable subsistence, drugs, and X-ray films, has been assigned support responsibility for all civilian agencies.

The Defense Supplu Agency (DSA) is an agency of the Department of Defense. Starting in 1955, "single manager" agencies within the military departments began to reduce supply inventories and operating costs, while maintaining effective support of the Army, Navy, Air Force, and Marine Corps. In 1961, following a survey to determine the possible extension of management into other areas, the Secretary of Defense established DSA to manage procurement and distribution of common supplies and to perform certain logistic service support of the Armed Forces and assigned Federal civilian agencies. For example, the DSA is responsible for purchasing motor oil for all agencies of the Government.

Use of Specifications

Government purchasing of a product or a service normally involves a requirement for competitive bidding by suppliers. Competition is not a procurement technique; it is a phenomenon of the marketplace and is desirable if the purchaser seeks the lowest price. Each invitation for a bid (which is advertised) includes specifications, and often the specification mentioned in the invitation will also reference other specifications and standards.

To fulfill a user's need, commercial products must be of the required quality; therefore, supplies, equipment, and commodities purchased by the Government are usually subject to inspection and test by Government representatives before payment of the contractor's invoices. Inspection is necessary to determine that the goods offered meet all technical requirements of the contract, including those contained in referenced specifications and standards.

Most Government contracts for commercial products provide for inspection of the products before they are accepted by the Government. Both GSA and DSA have an extensive quality control program to support the procurement function. The Veterans Administration performs quality control inspections on medical items for which it is responsible, and the Department of Agriculture and the Food and Drug Administration operate extensive inspection programs in support of public health and safety.

DIRECT AND INDIRECT PURCHASING

Government agencies not only write specifications for products that they buy for their own use, but the Federal Government also sets guidelines, standards, and specifications when it provides funds, grants, etc., to state and local governments and certain private enterprises and individuals. Revenue sharing is one approach. For example, both Federal and state governments supply funds for building highways and other public structures. Another technique whereby the Federal Government regulates segments of private industry includes offering tax writeoffs, favorable financial terms, or easy credit, etc., if private industry follows Government guidelines and specifications.

In other cases, Federal regulations are not backed by funds, but they are designed to affect purchasing in the private sector. For example, Federal statutes and regulations are used to protect the public consumer in the production, processing, and distribution of food in the United States--a $140 billion per year business. These measures are designed to prevent disease, improve sanitation, and raise quality levels. Though annual direct Government purchases of food are only $4.6 billion,[1] the remaining purchases are still affected by these Government regulations.

These examples, cited above, where the Government is not the consumer, are considered indirect purchasing; and examples where the Government is the consumer are considered direct purchasing. Early in our study, we were directed by EPA to focus our efforts only on the direct purchasing of goods by the Federal Government. But, actually, indirect purchasing can affect a larger percentage of the domestic output of our economy than can direct purchasing. Federal food standards are only one example of Federal standards that affect the purchases of the private sector; for example, the Department of Transportation has safety standards that apply to all automobile tires. Changes in these standards, then, can affect the purchase of all automobile tires in the United States.

Another very important example of indirect purchasing by the Government is new construction. The Federal Government, for example, sets the specifications for highway construction, and these are used by state and local governments and private citizens. In 1970, almost $10 billion was spent for highways in this country; that year, Federal, state, and local governments spent more than $27 billion on new construction (Table 1). In almost every instance, Federal specifications and standards were used to purchase the goods and services shown in Table 1. About 65 percent of the value shown in the table is for materials, and

TABLE 1

VALUE OF NEW CONSTRUCTION PUT-IN-PLACE WHOLLY FUNDED BY FEDERAL, STATE, AND LOCAL GOVERNMENTS (1970)

(millions of current dollars)

Category	Output
Highway	9,840
Military	871
Flood Control, Harbors, and other	1,619
Sewer Systems	1,230
Water Systems	1,538
Public Residential	857
Public Industrial	487
Public Educational	5,638
Public Hospital	743
Administrative, Service, and other	2,358
Public Service Enterprises, others	2,255
Total	27,436

Source: Arthur D. Little, Inc., Input/Output Computer Model of U.S. Economy the remainder is for services. In fiscal 1972 an estimated $39.1 billion was expended through Federal grants for construction and other products and services.[1]

Thus, changing the specifications and standards used in indirect purchasing by the Federal Government may indeed offer a very effective way of modifying the goods purchased by the larger non-governmental sector. We believe that a study of the use of indirect purchasing by the Government to reduce solid waste may be very fruitful.

STATISTICS ON DIRECT PURCHASING

As indicated in Table A-1, in 1971, a total of $60.6 billion was spent by the Federal Government for goods and services in direct purchasing. Most of these expenditures were made by the Department of Defense (Table 2), according to the report of the Commission on Government Procurement.[1] In fiscal year 1972, the Department of Defense spent 68.5 percent of the Government budget for supplies and services, whereas the civilian agencies spent 25.2 percent. Other procurements amounted to 6.3 percent of the budget; for example, for services such as executive printing by the Government Printing Office (GPO) and Government bills of lading. In 1972, most of the Federal military procurement went for aircraft, ships, weapons, and related services ($12.5 billion), another $5.8 billion went for research and development, and $15.3 billion went for commercial equipment, material, and services.

The Federal Government buys products for which it is the only user, and it also buys products for which it is but one of many users. Items for which the Government is the only user are normally highly sophisticated products that do not have a commercial market. These include, for example, major weapon systems, such as aircraft and warships. On the other hand, commercial products are developed to meet the needs of many users rather than those of any single customer. These items are subject to the competitive forces of a free market with the cost of improvements being borne by the private developer and being reflected in the price of his product to the extent competition will permit. In general, commercial products are dynamic rather than static.

Acquisition of commercial products represents a major portion of the Federal procurement budget. However, most industries that produce commercial products sell only a relatively small share of their total output to the Government. For example, of the 178 product groups (SIC Code) representing industries that manufacture primary products, as reported in the 1967 Census of Manufactures,

TABLE 2

ESTIMATED GOVERNMENT EXPENDITURES FOR PROCUREMENT AND GRANTS BY AGENCY, FISCAL 1972
(billions of dollars)

Agency		Total
Department of Defense		39.35
Civilian executive agencies		
Atomic Energy Commission	2.88	
Department of Agriculture	2.62	
National Aeronautics and Space Administration	2.48	
General Services Administration	1.31	
Veterans Administration	0.74	
Department of Health, Education and Welfare	0.72	
Department of Transportation	0.70	
Department of the Interior	0.65	
Department of Labor	0.38	
Department of Housing and Urban Development	0.25	
Tennessee Valley Authority	0.23	
Department of State	0.20	
Department of Commerce	0.17	
Department of the Treasury	0.16	
Other agencies	1.00	14.49
Other expenditures which should be classified as procurement		
Executive printing by GPO	0.18	
Blind-made products	0.02	
Government bills of lading	1.05	
Government transportation requests	0.38	
Commercial utilities and communications	1.50	
Rents paid by GSA	0.51	3.64
Total estimated Government procurement		57.48

Source: Report of the Commission on Government Procurement
December 31, 1972.

125 ship 2 percent or less of their output to the Government. Of the remaining 55, only 9 ship more than 10 percent to the Government.

Although the Federal market is small, relative to the total market for commercial products, nevertheless it represents the largest single concentration of purchasing power in the United States. The Government purchases commercial products from wholesalers and manufacturers. Of the over 250,000 wholesale establishments reporting $228 billion sales in the 1967 Census of Business, the overall average percentage of sales to the Government was 1.6 percent. Only six groups of wholesalers showed sales to the Government amounting to more than 3 percent of total sales (Table 3).

As a first step for determining how effective Federal procurement policy can be used as an incentive to reduce solid wastes, we calculated Government expenditures for goods as a percentage of the domestic output for each commodity sector on the ADL input/output model. Thus, based on the data shown in Table A-1 and the corresponding statistics for the expenditures by the private sector and state and local governments in each of the ADL sectors, we placed the sectors into three groups according to whether the Government spent: (1) more than 5 percent of the domestic output; (2) between 2 and 5 percent; and (3) less than 2 percent. These results are shown in Tables 4, 5, and 6.

According to this tabulation, few of the Federal Government expenditures for commodities amount to as much as 2 percent of the total domestic output. Many of the commodity sectors shown in Table 4 are items where the Government is the sole purchaser; for example, ordnance, aircraft, and parts. Other examples include products that are highly sophisticated. Any effort to change the specifications of these products would involve very extensive research programs to ensure that the necessary performance requirements were met. On the other hand, ADL Secton No. 147 (Table 4), office supplies, accounts for almost 8 percent of the domestic output. The products in this sector include such items as stationery, magnetic tapes, business forms, ledgers, adhesives, rubber bands, erasers, staples, paper clips, etc. Another significant category in Table 4 is ADL Sector No. 117, communication equipment. This category includes products such as radio and television receiving sets, phonograph records, telephone and telegraph apparatus, and a variety of radio and television communication equipment.

TABLE 3

PERCENTAGE OF SALES TO THE GOVERNMENT BY WHOLESALERS: ABOVE 3 PERCENT

Product Line	SIC Code	Sales to the Government (%)
Dairy products	5043	7.8
Electronic parts and equipment	5065	5.7
Transportation equipment (excluding motor vehicles)	5088	4.7
Printing and writing (fine) paper	5096	3.3
Commercial machines and equipment	5081	3.3
Amusement and sporting goods	5099	3.1

Source: 1967 Census of Business, Wholesale Trade Sales by Class of Customer, Department of Commerce. September 1970, table 1.

TABLE 4

GOVERNMENT EXPENDITURES AS A PERCENTAGE OF DOMESTIC OUTPUT: ABOVE 5 PERCENT

ADL Sector				
No.	Commodity	Defense 1970	Non-Defense 1970	Total 1970
6	Nonferrous Ore Mining	18.10	0.51	18.61
12	Maintenance Construction	3.86	2.69	6.55
13	Ordnance	55.63	19.39	75.02
57	Industrial Gases	3.37	3.06	6.43
61	Industrial Organic Chemicals, n.e.c.	10.69	0.52	11.21
80	Explosives	45.52	2.32	47.84
104	Engines and Tubines	5.69	0.99	6.68
107	Materials and Handling Equipment	4.54	0.50	5.04
110	General Industrial Machine & Equipment	4.72	0.41	5.13
112	Office Computing and Accounting Machines	4.36	1.67	6.03
114	Electric Apparatus and Motors	4.88	0.91	5.79
117	Communication Equipment	27.47	3.96	31.43
118	Electronic Components	7.65	1.17	8.82
119	Batteries, X-Ray & Eng. Elec. Equipment	5.31	0.82	6.13
123	Aircraft and Parts	35.26	5.26	40.52
124	Ships, Trains, Trailers & Cycles	14.84	4.06	18.90
125	Instruments and Clocks	7.04	2.28	9.32
126	Optical and Photographic Equipment	3.43	1.96	5.39
147	Office Supplies	4.28	3.57	7.85

Source: Arthur D. Little, Inc.

TABLE 5

GOVERNMENT EXPENDITURES AS A PERCENTAGE OF DOMESTIC OUTPUT: BETWEEN 2 AND 5 PERCENT

ADL Sector No.	ADL Sector Commodity	Defense 1970	Non-Defense 1970	Total 1970
27	Household Textiles & Upholstery	1.96	0.23	2.19
62	Industrial Inorganic Chemicals, n.e.c.	3.76	----	3.76
67	Biological Products	1.03	2.72	3.75
75	Gum & Wood Chemicals	0.03	3.58	3.61
84	Petroleum Refining	3.35	0.31	3.66
88	Miscellaneous Rubber Products	3.35	0.17	3.52
106	Constructiong & Mining Mach. and Equipment	2.74	0.18	2.92
111	Machine Shops & Miscellaneous Machinery	2.00	0.06	2.06

Source: Arthur D. Little, Inc.

TABLE 6

GOVERNMENT EXPENDITURES AS A PERCENTAGE OF DOMESTIC OUTPUT: LESS THAN 2 PERCENT

ADL Sector				
No.	Commodity	Defense 1970	Non-Defense 1970	Total 1970
1	Livestock	neg.	0.02	0.02
4	Agriculture, Forestry and Fishery	1.31	0.01	1.32
5	Iron & Ferro Alloy Ores Mining	1.70	(-0.79)	0.91
7	Coal Mining	1.42	0.24	1.66
9	Stone and Clay Mining and Quarrying	0.42	(-0.31)	0.11
10	Chemical and Fertilizer Mineral Min.	0.05	0.01	0.06
14	Meat Packing	0.42	0.14	0.56
15	Dairy Products	0.69	0.67	1.36
16	Canned and Frozen Goods	0.17	0.10	0.27
17	Grain Mill Products	0.08	0.87	0.95
18	Bakery Products	0.13	0.07	0.20
19	Sugar	0.09	0.04	0.13
20	Confectionery & Related Products	0.03	0.02	0.05
21	Beverages	0.09	0.03	0.12
22	Miscellaneous Food Products	0.05	0.30	0.35
24	Fabrics and Yarn	0.29	neg.	0.29
25	Rugs, Tire Cord and Miscellaneous Textiles	0.21	0.11	0.32
26	Apparel	0.26	0.17	0.43
29	Sawmill & Planning Mill Products	neg.	----	neg.
34	Wooden Containers	1.08	0.01	1.09
35	Wood Preserving & Miscellaneous Products	0.42	0.23	0.65
36	Household Furniture	0.23	0.27	0.50
37	Office Furniture	0.67	1.26	1.93
39	Paper Mills, ex. Building Paper	0.13	0.40	0.53
40	Paperboard Mills	0.09	0.03	0.12
41	Coated and Converted Paper	0.32	0.21	0.53
43	Sanitary Paper Products	0.34	0.56	0.90
44	Cardboard Boxes	0.23	0.09	0.32
45	Corrugated & Solid Fiber Boxes	0.12	0.05	0.17
47	Fiber Cans	1.12	----	1.12
48	Newspapers	0.01	0.01	0.02
49	Periodicals	0.01	neg.	0.01
50	Book Printing and Publishing	1.19	(-0.88)	0.31

ADL Sector				
No.	Commodity	Defense 1970	Non-Defense 1970	Total 1970
51	Commercial Printing	2.69	(-0.85)	1.84
59	Cyclic Intermediates and Crudes	0.35	----	0.35
60	Inorganic Pigments	0.92	----	0.92
63	Plastics Materials and Resins	0.51	neg.	0.51
64	Synthetic Rubber	0.31	----	0.31
65	Cellulosic Man-Made Fibers	1.38	----	1.38
66	Organic Fibers, Noncellulosic	0.58	----	0.58
68	Medicinals and Botanicals	0.58	----	0.58
69	Pharmaceutical Preparations	0.98	0.88	1.86
70	Soap and Other Detergents	0.42	0.09	0.51
71	Polishes and Sanitation Goods	0.87	0.40	1.27
73	Toilet Preparations	neg.	----	----
74	Paints and Allied Products	0.08	0.04	0.12
76	Fertilizers	0.03	1.09	1.12
78	Agricultural Chemicals, n.e.c.	0.34	0.39	0.73
83	Chemical Preparations, n.e.c.	1.40	0.10	1.50
85	Tire and Inner Tubes	1.42	0.08	1.50
86	Rubber Footwear	0.46	----	0.46
89	Miscellaneous Plastic Products	0.53	0.09	0.62
90	Leather Tanning	0.06	0.02	0.08
91	Shoes & Other Leather Products	0.11	0.02	0.13
92	Glass and Glass Products	0.28	0.21	0.49
93	Stone and Clay Products	0.34	(-0.07)	0.27
94	Primary and Secondary Iron and Steel	0.20	0.01	0.21
95	Primary and Secondary Copper	0.08	0.30	0.38
98	Primary and Secondary Aluminum	0.63	0.03	0.66
100	Metal Containers	0.29	----	0.29
101	Heat-Plumb-Structural Metal Products	0.51	0.09	0.60
102	Stampings, Screw Mach. Prods. Bolts	0.44	0.13	0.57
103	Hardware, Plating, Wire Prod. Valves	0.38	0.17	0.55
105	Farm Machinery and Equipment	0.36	0.04	0.40
108	Metalworking Machinery and Equipment	1.22	0.40	1.62
109	Special Industrial Machinery	0.28	0.27	0.55
113	Service Industry Machines	1.08	0.09	1.17
115	Household Appliances	0.16	0.04	0.20
116	Electric Lighting and Wiring Equipment	0.37	0.02	0.39
121	Truck Trailers	2.40	neg.	2.40
122	Motor Vehicles and Parts	1.57	0.16	1.73
127	Miscellaneous Manufactured Products	0.12	(-0.02)	0.10

CURRENT FEDERAL PROGRAMS THAT USE PURCHASING POWER TO REDUCE THE GENERATION OF SOLID WASTES

General Services Administration (GSA)

In 1971, under the direction of the President, GSA undertook a role of national leadership in promoting the recycling of solid wastes for the production of new items--it changed specifications for certain paper products to require recycled material. GSA is responsible for purchasing commodities in FSC Class 9310, which consists of paper and paperboard products, such as book paper stock, newsprint, paperboard, and a variety of bulk paper materials. GSA also manages Class 8540, which includes toilet tissue and paper towels. Most significantly, GSA is also responsible for FSC Classes 8115 and 8135, which include boxes, cartons, crates, and a variety of packaging and packing materials. Any Government agency, civilian or military, that requires these materials purchases them from GSA through the Federal Supply Service. GSA purchases more than $100 million of paper products annually.

Initially, GSA changed 14 specifications for paper products to require recycled material. These specifications were selected first because they accounted for the largest dollar volume ($35 million) of sales. In total, GSA is responsible for 122 specifications. In developing the new specifications, GSA met with the Forestry Service of the Department of Agriculture and private associations, such as the American Paper Institute (API), and the National Association for Secondary Material Industries (NASMI).

Because the effect of secondary material on the properties of the resulting paper products is not well known, GSA began by requesting relatively low concentrations of recycled fiber, and then increased the requirements in subsequent bids. In this way, they could empirically determine the limiting concentration of reclaimed fiber. When the concentration level is reached, where industry does not respond to bids, GSA lowers their requirements. In this way, they hope to maximize the use of reclaimed fibers. (The definition of reclaimed fiber used by GSA in their specifications appears in Appendix B, Exhibit B-2.)

Today (1973), GSA has 77 modified specifications for paper that require recycled material. In some instances, during this program, GSA found that industry was unable to supply the requested products and still meet the new GSA requirements for reclaimed fiber. For example, GSA originally requested toilet tissue with 50 percent reclaimed fibers from sources listed in Part 1 of their definition (Exhibit B-2) and 20 percent from post-consumer waste, for a total of 70 percent reclaimed fiber. Because industry was unable to respond to this specification, GSA dropped the requirement for post-consumer waste; therefore, only 50 percent reclaimed fiber from sources listed in Part 1 are specified today.

GSA has also found that the maximum concentration of reclaimed fiber that it could specify in corrugated cases (Specification PPP-B-639H) was 35 percent--25 percent defined as reclaimed fiber from the sources listed in Part 1, and 10 percent from post-consumer waste.

In other programs, the GSA has modified its specifications for tires and removed the prohibition against the use of virgin material. Similarly, it has removed the prohibition that prevented the use of secondary plastic material in plastic pipe and fittings. These modifications were made while our study was in progress and at our recommendation.

In another effort, as the specifications come up for revision, the GSA is reviewing them broadly in an attempt to modify the packaging requirements. The specifications are being reviewed to determine whether less packaging material can be utilized, while still meeting the necessary packaging performance requirements.

Defense Supply Agency (DSA)

DSA is responsible for purchasing and specifying motor oil for all agencies of the Government. Currently, DSA is considering the feasibility of using recycled lubricating oils in the Federal Supply System. Because large volumes of spent lubricating oil are drained in only a few Government-operated centers, the Government is in an excellent position to recover this waste oil and thereby promote recycling. In 1970, in the Continental United States, the Department of Defense alone used 10.5 million gallons of engine lubricating oils, 1.6 million gallons of aircraft engine oils, and 45 million gallons of other oils, greases, and solvents.

DSA also has active studies to investigate the possibility of using more reuseable packaging materials. For example, some of its supply centers are trying to reuse the wooden shipping containers that they often receive with their purchased goods for various repackaging operations. Further, the development and use of intermodal containers for commercial and military land, sea, and air movement have demonstrated economic and environmental benefits.

Government Printing Office (GPO)

The Government Printing Office, which is responsible to the Congressional Joint Committee on Printing, prepares specifications for Government purchases of writing and printing paper used by many of the Government agencies. In total, the GOP manages about 85 specifications. About one-third of the paper that GPO specifies and purchases is used by GPO; approximately one-third is used by GSA, and another one-third by DSA. The GPO alone buys about 30 million pounds of printing and writing paper.

In 1971, the Joint Committee carried out a study to determine whether they could change the specifications for the writing paper to include reclaimed fiber as the raw material. The report was never made public, and the specifications remain unchanged.

U.S. Navy

The U.S. Navy, together with the U.S. Army Natick Laboratories, is examining the possibility of changing the specifications for packaging materials used aboard ship. More than 50 percent of the solid wastes generated aboard ship arise from packaging. The objective of this program is to reduce the weight of packaging materials used for subsistence items 50 percent by 1975.

The Navy commissaries are also considering the possibility of modifying their purchases consistent with the objectives of reducing solid waste. For example, in California, the Navy exchange commissary stores had an experimental contract with a firm to recycle the corrugated shipping cases used for shipment of purchased goods.

The Navy, like the DSA, receives a large amount of wood in the form of crating, blocking, and bracing material. In one location, they reduce the volume of this wood waste by converting it to chips, which are then sold to a commercial firm that manufactures pressed-board products. The Navy also sells used wood to the general public on an "as is" basis.

U.S. Air Force

The U.S. Air Force also has an experimental program to study the possibility of reusing materials. It is examining the feasibility of reusing the corrugated cartons employed in moving Air Force personnel, and plans to write contracts that will require the carrier to remove the cartons for reuse, after the move is complete. The Air Force also is considering the redesigning of these cartons especially for reuse.

APPROACH TO STUDY

Faced with considering a very large array of product specifications, the initial question was how to decide which products represent the best opportunities to reduce solid waste. In developing criteria for selecting these opportunities, we were aware of the following facts:

1. The urban solid waste stream contains approximately 50 percent paper, 10 percent metals, 10 percent glass, and about 2 percent each of plastics, textiles, and rubber.

2. Before reaching the solid waste stream, these materials are found in a wide variety of products in the United States.

3. These products are generally sold to satisfy broad markets such as transportation, construction, household goods, etc.

4. Within each material category the distribution of products sold in the various markets varies. For example, about 75 percent of our rubber is used in tire and tire products. These, then, are the major products in this category. On the other hand, some of the major paper products may account for only about 20 percent of all paper and paperboard consumed.

5. Changing product specifications consistent with the objectives of this study can affect product performance.

6. Some items purchased by the Government are consumed; for example, foods, detergents, explosives, etc. These were immediately eliminated from the list of opportunities (Table 7).

7. Packaging is used extensively by the Government. According to officials at DSA, the Government probably uses as much as 10 percent of all packaging materials produced in the United States. As noted above, each Government product specification has packaging instructions; consequently, though consumables were eliminated from

TABLE 7

ADL SECTORS NOT CONSIDERED SOLID WASTE OPPORTUNITIES

ADL Sector number	Commodity
1	Livestock
14-20	Subsistence Categories
57	Industrial Gases
59	Cyclic Intermediates & Crudes
60	Inorganic Pigments
61	Industrial Organic Chemicals
62	Industrial Inorganic Chemicals
67	Biological Products
68	Medicinals and Botanicals
69	Pharmaceutical Preparations
70	Soap & Other Detergents
71	Polishes & Sanitation Goods
73	Toilet Preparations
74	Paints & Allied Products
75	Gum & Wood Chemicals
78	Agricultural Chemicals
80	Explosives
83	Chemical Preparations
84	Petroleum Refining*

* Lubricants which are included in this sector are potentially recyclable and, therefore, are not included in this list.

Source: Arthur D. Little, Inc.

consideration, we still had to consider the packaging used for the consumable items.

8. Certain purchases by the Federal Government have high public visibility. These are commercial products that are used widely by the population. For example, most of the population purchases a variety of paper goods, but few purchase products such as aircraft and rockets. If the product is purchased by most, then the Government potential can influence purchasing patterns not only of state and city government but the private sector as well.

9. Some Government suppliers manufacture the specified products, but others are themselves purchasers of the specified products. For example, in purchasing canned foods from the canners, the Government specifies the packaging material used for shipment, but the canner purchases this packaging material from another manufacturer.

Fact No. 8 is very important. If a given Government purchase has high market visibility, the Federal Government can exert its leadership role and influence purchasing patterns not only of state and city governmental units, but of non-governmental units as well. When this effect exists, it essentially behaves as a multiplier, and increases the impact of Federal Government purchasing and, thereby, introduces a "ripple" effect throughout the domestic economy. We believe that to eliminate this criterion without testing the phenomenon to see how real and significant it is would be misleading.

The "Ripple" Effect

In its recent report,[1] the Commission on Government Procurement recognized that procurement expenditures can generate some three times their amount through the multiplier effect. These arise from secondary and related service spending, according to the Commission.

Examples - In certain areas, Federal procurement can play a catalytic and leadership role in bringing Government developed standards and products into practical commercial use. In the case of standards, these range from automobile safety standards to standards for fire-resistant materials. In the case of products, these range from advanced solid-state computer components to superior jet engine parts. In fact, entire segments of industry have been spawned by technological breakthroughs and spinoffs from Government procurements for electronics, metallurgy, fuels, and lubricants. For example, the Federal Government did research on the combustors of jet engines to reduce particulates. This research work was successful and was immediately adopted by the civilian aircraft industries in their specifications.

Another example is the development of safety equipment on boats. This work was done by the Coast Guard and later adopted by the civilian industries. In general, where the Government has specifically required special sophisticated hardware, the Government often has taken a leadership role, and the civilian sector has followed. Today, many specifications used by industry for wire insulation were originally developed to meet Federal Government needs. In these cases, when the civilian industry recognized that Government specifications represented advanced technology, they were often adopted.

As mentioned above, the GSA has recently taken a leadership role in modifying its specifications to introduce reclaimed fiber. As a result, many state governments have requested more information concerning these specifications and are considering the possibility of changing their existing specifications for paper to include the use of reclaimed fiber. Thirty states have requested information (see Appendix B, Exhibit B-3), and many of the large cities are watching these developments closely. The City of New York, for example, has recently changed its paper specifications to include recycled fiber.

Many large U.S. companies use considerable quantities of paper. (Some use as much as the Government.) These companies, too, are reviewing their specifications. For example, AT&T is doing a wholesale review of its paper specifications, and plans to require reclaimed fiber in a number of its paper products. The company not only plans to introduce this new requirement for the paper used in telephone books, but also to revise its specifications for paper used in office forms.

The Coca Cola Company also has reviewed its specifications, and has decided to use recycled fiberboard for its beverage carrying cases. Originally, the company was required to do so to meet the specifications for that portion of its products sold to the U.S. Government; now it has decided to use this recycled fiberboard for all of its requirements.

Procter & Gamble is also following the Government lead, and it, too, will be requiring reclaimed fiber in much of its packaging material. Many non-profit organizations, such as PTA and the League of Women Voters, use recycled fiber in their printing papers.

Obviously, then, the "ripple" effect exists, although no doubt the extent varies with the product. The more widely the product is used in our economy, the greater the likelihood of a "ripple" effect, and the greater its magnitude. We believe that to estimate the "ripple" effect in any quantitative manner would not be meaningful, because too many unknown factors are involved. However, a major factor that must be considered is the extent of the response by the supplying industries to the Government's request for bids for products with reclaimed material. Industry, after all, is not obliged to sell to the Government.

Mechanisms for Promoting the Effect - In our study we recognized that certain conditions should be met if the "ripple" effect is to be substantial. We have already noted one requirement--that the purchased product should be used by a major segment of the population. Second, if the modified product specification requires secondary material, this material must be readily available. If industry does not have facilities to manufacture the product containing the secondary material on a large scale, the "ripple" effect will be minimal. For example, when the Federal Government changed its requirements to promote the use of non-leaded gasoline in Government installations, essentially no "ripple" effect occurred because, at that time, an insufficient quantity of non-leaded gasoline was available in the United States.

Assuming that these two conditions are met, the Government is in a position to use special strategies to promote the "ripple" effect. Thus, the Federal Government could purchase the specified product from a supplier who is not the manufacturer of the specified product but is an intermediate purchaser of the specified product. The case cited above (Fact No. 9) is an excellent example, where the Government purchases canned goods from a canner who ships these cans in a corrugated shipping case. The canner only purchases the corrugated shipping cases. Thus, the canner, to meet the specifications of the Government, has to specially order corrugated cases specified by the Government. To avoid double stocking of these cases, the canner would prefer to buy one product and, if the specified shipping case is available, the canner would tend to purchase his entire stock from the corrugated manufacturer who meets the Government specifications.

Note that the Coca Cola Company did just this when the Government changed its specifications for the fiberboard carrying cases.

In general, then, when a product is purchased as part of a larger unit, the possibility of a "ripple" effect is increased. For example, if the government changes the specifications for original-equipment tires, an effective way of promoting the "ripple" effect would be to request automobile manufacturers to meet this specification. Again, the automobile manufacturer does not manufacture tires, but he is one of the largest purchasers of this product.

An alternative mechanism available for the Government to promote the "ripple" effect is to broadly publicize its programs to modify specifications to reduce the generation of solid waste. To a certain extent this is what the Government did when it began its program to modify the specifications for paper products to incorporate reclaimed fiber.

Significance in this Study - As noted above, the "ripple" effect is difficult to estimate quantitatively. However, even if the "ripple" effect fails to occur, introducing this concept as a working hypothesis in this study is appropriate because it represents an optimistic extreme that can be used in analyzing the impact of recommendations that we make.

If some of our recommendations are negative despite the "ripple" effect, the use of Federal Purchasing Policy alone as a tactic to reduce the generation of solid waste does not provide an adequate incentive.

Development of Selection Criteria

On the basis of these facts, the preceding information, and the "ripple" effect concept, we attempted to list all possible criteria for selecting a product category as a solid waste reduction opportunity. These criteria were placed into three groups, depending upon whether they involved economic, disposal, or technical characteristics (Table 8).

This search for criteria was a continuing effort, as we sought to make the list complete. Note that many of the criteria listed in Groups A and B are essentially measurable; that is, they are quantitative criteria. In contrast, many of the criteria in Group C are not easily measured, are dependent upon subjective factors, or require research.

TABLE 8

CRITERIA FOR SELECTION

A. ECONOMIC

*1. Percentage of population purchasing and/or using the product
*2. Percentage of total output of product purchased by Government.
3. Domestic output of product as a percentage of total domestic output
4. Projected future Government needs for product.
5. Competitiveness of Government procurement of product.
6. Supplier or manufacturer or intermediate purchaser of specified product.
7. Specified product is purchased alone or as a unit combined with other goods.
8. State of market for secondary material used in manufacture of product.
9. State of market for virgin material needed for the manufacture of product.
10. Relative economics of using secondary vs. virgin materials in the manufacture of the product.

B. DISPOSAL

*1. Percentage of spent product and the materials used in the product's construction in urban solid wastes.
2. Projected concentration of spent product in urban solid wastes.
3. Disposal characteristics.
4. Availability of separate collection of the spent product at the source or mechanical separation at the final disposal area at present and in the future.
5. Service life of product.

C. TECHNICAL

1. Existence of product specifications and standards restricting the raw materials to virgin materials.
2. Concentration of secondary material that can be incorporated in product without reducing the necessary performance characteristics.
3. Present concentration of secondary material in product.

4. Availability of technology to utilize secondary material in product.
5. Ability to modify specifications of product to promote recyclability characteristics without reducing necessary performance.
6. Ability to modify specifications of product to reduce weight or volume of product without reducing necessary performance requirements.
7. Amount of pollution generated in manufacturing product from virgin or secondary material and geographical location (city or rural) of manufacturing site.

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* Primary Criterion

Source: Arthur D. Little, Inc.

Furthermore, analysis of these criteria indicated that some had so large a direct impact on the objectives of this study that they could not be excluded, and these same criteria were independent of any strategy for changing the product specification to increase recycling or reduce solid wastes. In contrast, other criteria were completely dependent upon the method selected for changing the specifications of the product. The former criteria (A-1, A-2, and B-1 - Table 8) were considered primary criteria, and were used in the initial selection process.

To insure that nothing was overlooked, we applied these primary criteria simultaneously. They pointed us toward collecting particular data to be used in the selection process; for example, many of the primary criteria call for statistical data as percentages. Note also that the primary criteria reflect two characteristics--economic and disposal.

In our initial screening of products, then, we asked three questions based on the primary criteria:

1. What percentage of the total domestic output of the product is purchased by the Government?

2. What percentage of the population purchase and/or use the product?

3. What percentage of the spent product is in the solid waste stream?

If the response to any of these questions was zero, the product could justifiably be removed from the list, unless the product had a long service life and could use secondary material; e.g., items of construction. Thus, if the Government did not purchase the product, it was removed from further consideration. As noted earlier, few of the Government expenditures amount to as much as 2 percent of the total domestic output. However, if the response to any of the other questions was "more than 2 percent," the product was considered a solid waste reduction opportunity. In general, high percentages indicated superior opportunities. Thus a product that uses a material that generates a major proportion of the urban solid waste, such as paper, was considered a solid waste reduction opportunity; armaments were not.

Economic Criteria - The other criteria in this group are concerned with the availability of different mechanisms to promote a particular strategy for modifying the product specification. For example, Criteria A-6 and A-7 are concerned with mechanisms for promoting the "ripple" effect; most of the others deal with the use of secondary material, if the specification can be written to include the material.

In promoting recycling by modifying product specifications to include recycled material, an important consideration is the market for the secondary material used in the end product. For example, today the market for most secondary metals is a good one. If the metal is available (relatively free of contaminants), it usually can be sold. On the other hand, secondary plastics have a very limited market at the present time, unless they are derived from clean industrial scrap. Thus, in selecting a product category based on its ability to use recycled material, we considered products made from plastic materials as potentially greater opportunity areas than products made from metals, other factors being equal.

The availability of the virgin material required to manufacture a product was also considered in the selection process. For example, if we are concerned with a product that uses a material that will become less available with time, such as petroleum-based products, then these products would be selected over another that uses materials that are readily available today and will be in the future. Clearly, in this instance, recycling implies conserving natural resources.

Competitive bidding is another factor. Usually, the more competitive this bidding, the lower the cost of the product to the Government, other factors being equal. For example, if incorporating secondary material in the selected product tends to increase costs to the manufacturer, these costs would be less likely to be passed on to the Government if a large number of companies were bidding.

Disposal Criteria - If recycling is an appropriate strategy that can be introduced by a specification change, it is also essential that sources of secondary material be available. Thus, as indicated by Criterion B-4, either source-separated or mechanically separated materials must be available in the near future. For example, plastic products in the disposal area are not easily retrieved economically; consequently, plastic post-consumer wastes will probably not be available in the near future. On the other hand, ferrous metals are easily retrieved by magnetic separation; potentially, then, these materials will be available.

The service life of a product is significant, as noted earlier. Products with a long service life that can use high concentrations of secondary material represent a greater solid waste reduction opportunity than products with a short service life, other factors being equal.

Criteria concerned with the disposal characteristics of a product are relatively subjective today because this information is not readily available. In general, in selecting a waste reduction opportunity, we selected a product that we judged to be difficult to dispose of through the normal channels over one that caused few problems, assuming that other factors were equal.

Technical Criteria - These criteria are concerned with the technical performance requirements of the product and include a variety of criteria ranging from those that are easily measurable to those that are completely subjective.

Many products contain secondary material today, and some are manufactured wholly from secondary material. These products, then, represent poor solid waste reduction opportunities, as compared to products that contain only a limited concentration of secondary material today, assuming that the concentration incorporated in the latter product can be increased without reducing the necessary performance characteristics. The technology related to using secondary materials was certainly an important factor to be considered in making the selection; but in many instances the technology was not the limiting factor. More often, the economics of using secondary materials was the more significant constraint.

But specifications can be modified not only to require the incorporation of secondary material. They also may be modified to promote the recyclability characteristics of a product; for example, by requiring the use of only one material. Thus, the Government could specify the purchase of all-steel or all-aluminum containers.

In some instances, the specifications could be changed to reduce the weight or volume of material in the product without reducing its necessary performance characteristics. For example, the Government could specify the use of lightweight paper; or, in the packaging area, the Government could specify the use of polyethylene sacks rather than rigid plastic containers as the packaging material.

Screening

After developing the selection criteria, we divided all Government purchases of products into the usual material categories found in the solid waste stream--paper, metals, glass, plastics, textiles, and rubber. Packaging was added as a separate category. It represents a product rather than a material, and different materials are used in its construction. Packaging is obviously significant in the solid waste stream, and it is also an important part of Government product specifications, as noted above.

Each material and product category was assigned to an industry specialist who was familar not only with the technical characteristics of the product or material but also with the economics and the industry. The specialists first prepared lists of products based on the Federal Supply Classification Code and used the primary criteria developed above to make the initial selection of the most appropriate products to be examined in greater depth.

In the selection process, products having a long service life, particularly items of construction, were viewed as potential solid waste reduction opportunities, if these items (for example, wall board, road pavement, and sewer pipe) could use recycled material.

When this initial selection process was completed, we found that we had eliminated a very large number of products in all categories except metal. Fewer than 50 items remained in most categories; but in the case of metal products, about 200 items remained. At this point the actual specifications were ordered and collected. We also found that even if the "ripple" effect discussed above were not introduced in this initial screening process, we still would have selected the major commodities in a given material category, based on the volume of products consumed in the United States, because the Government, like other consumers, purchases more of these commodities.

Alternative Ways of Changing Specifications to Reduce the Generation of Solid Wastes - Before proceeding with the screening phase using the secondary criteria, we examined alternative ways of changing the product specifications to reduce the generation of solid wastes.

As noted earlier in this section, the Government has usually changed product specifications by allowing recycled material to be used in the purchased product. In other instances, the Government is considering new specifications for the redesign of products especially for reuse. Note that both of these approaches require a collection system either to collect the spent product for reuse or to recycle it as secondary material. This is a significant constraint, because few systems are available today, especially for the collection of post-consumer wastes.

Other approaches for changing specifications similarly require a collection system; for example: (1) to make the product more easily recyclable (more homogeneous, etc.), and (2) to design a product that uses the collected waste as a secondary material not in the original product but in a secondary application. The latter approach is exemplified by employing used chopped tires for road pavement and used glass for bricks, etc.

However, there are other ways of changing product specifications to meet the objectives of this study without requiring the use of a collection system. For example, the use of less material can be specified in the manufacture of a product. In this approach, less solid wastes are generated, assuming that the product still meets the necessary performance requirements.

Another approach is to design a product for a given application with an extended service life. This strategy, for example, can be significant in a number of cases. Consider appliances. Over the past 20 years, the average service life of some appliances has been decreasing rather than increasing. Arresting this trend and turning it around could have an important impact on the generation of solid wastes. Or, consider tires--doubling the service life of tires can reduce the solid waste load by one-half. Again, a very effective approach.

Secondary Criteria - The appropriate alternative strategy for changing the product specification to reduce the generation of solid waste was selected after the specifications were ordered and analyzed. Then, the secondary criteria (Table 8), which are primarily technical, were applied. Here, each of the industry specialists had to judge whether the performance requirements could be met if, for example, the concentration of secondary material in the given product was increased, or the weight reduced. Similarly, our specialists also considered the strategy of promoting the recyclability of a product by modifying its specifications.

Secondarily, each specialist also ordered and reviewed specifications for products suspected to resist the use of secondary raw materials. This was not a comprehensive process, and depended primarily on each specialist's past experience and familiarity with the Government product specifications in their material category. Furthermore, many of the products selected in this phase are significant ones that are purchased in our economy.

Examples - In the sections that follow, the selection process is described under each material category: paper, metals, glass, and rubber. Because of the lack of sufficient funds, the study of the remaining categories is incomplete. However, products were selected in all of the material categories, and those not discussed in the following sections are discussed below.

Plastics. Plastics represent about 2 percent of solid wastes. We found that many of the Government specifications for plastic products are restrictive, because they disallow the use of secondary material outright, or they disallow the use of purchased scrap in the manufacture of the product.

On the basis of our criteria, we selected two major plastic products--plastic pipe (in particular, corrugated drain tubing) and plastic insulation for wire and cable. Both products have long service lives and can use secondary material. However, Government specifications for these products disallow certain types of secondary material. Furthermore, both pipe and wire and cable are products that the Government buys directly and indirectly. For example, by indirect purchasing the Government provides financing to private purchasers. In this way, the Federal Government effectively purchases about 30 percent of all plastic pipe sold for irrigation and drainage in the United States. The indirect purchases of electric wire and cable by the Government account for a lesser percentage of total domestic output. But the combination of the Government's direct and indirect purchases of these products has a significant impact on all pipe and wire purchases in the United States.

Both plastic pipe and wire and cable markets are also growing very rapidly--faster than many of the other sectors of the plastics industry; therefore, they can provide a very substantial market for secondary material if the material can be collected. In addition, the technical feasibility of using secondary material in these products has been demonstrated, which again increases the attractiveness of these products as potential solid waste reduction opportunities.

Textiles. We first screened a complete list of products in this category to remove those items that are relatively insignificant in the U.S. economy or are not purchased by the Government. The following products remained after this screening--floor coverings, clothing, and padding and stuffing materials. Most of these items have relatively long service life, except for some articles of clothing; therefore, we considered Criterion C-2 (Table 8), which reflects the ability of the product to incorporate secondary material without reducing the necessary performance requirements. On this basis, floor covering was removed from consideration because this product usually cannot easily tolerate the incorporation of secondary material. Clothing items obviously are very important products, but at this time the information concerning how the presence of secondary material affects the performance of these products is insufficient for a decision. Because of these unknown factors, this product also was dropped from the list.

Finally, after further study, padding and stuffing materials were also dropped from the list. Although Government specifications for mattresses, etc., call for the use of new stuffing materials, specifications for mattresses for use by the public at large do not have this restriction. Therefore, changing the Government specifications to permit the use of secondary material would not significantly increase the market for reused fiber, because the Government alone purchases only a small percentage of the total domestic output of this product.

Packaging. As mentioned above, packaging is a product category rather than a material one, and it includes many of the materials already discussed. Needless to say, packaging is a very significant product in our economy. It also represents a sizable portion of the solid waste stream because it is a product with a very short service life and is used widely.

We recognized that packaging, overall, represents a significant area for solid waste reduction; however, because of budgetary constraints, we focused on just one of the most important markets for packaging--subsistence. For example, 35 to 40 percent of our food is delivered to us in cans (the primary package), and these cans are usually shipped to the wholesaler/retailer in corrugated shipping cases (the secondary package). Because of the importance of these types of packaging in our economy and the existence of new technology, we selected these packages, or rather this packaging system, for primary study.

METHODOLOGY USED TO ASSESS THE IMPACT OF CHANGING FEDERAL GOVERNMENT PRODUCT SPECIFICATIONS

Having selected the product area and the strategy for changing the product specifications to increase recycling and/or reduce solid waste, we proceeded to assess the impact this change would have on the particular industry that was immediately affected and, secondarily, on the rest of the economy. Primary effects on a particular industry under investigation included, whenever possible, the following impact variables: average costs of production, prices, output, and employment. We also considered the potential impact on the pertinent secondary materials industry and the environment.

However, in most instances these impact analyses were useful only in a very qualitative way because: (1) the technical information concerning the use of recycled material or the use of less virgin material in a selected product was unavailable, (2) the extent of the industry response to the modified specifications could not be easily determined, and (3) the "ripple" effect could not be quantitatively assessed. Nevertheless, we did develop a methodology for doing these analyses and, as more information becomes available, this methodology could be used to develop more quantitative response models. The linerboard example described in Section II is the most complete analysis. But even in this case numerous assumptions had to be made in the analysis; therefore, before the conclusions developed for the linerboard example can be considered valid, the assumptions would have to be tested.

In the impact analysis, we defined the impact period for the years 1972-1985, with 1972 as the base year, and 1978 and 1985 as the benchmark years. The impacts were then measured in terms of "deviations" from baseline forecasts that attempted to establish expected conditions for each selected product in the absence of any Governmental action.

To perform the analysis we specified three alternative scenarios:

- Scenario I represents no changes in Federal Government product specifications, no "ripple" effects resulting from Government persuasion, and no economic incentives. The baseline forecasts for the selected products were made under these assumptions. Under these conditions, the effect of the availability of the pertinent virgin and secondary materials on the variables mentioned above is considered wherever possible. The natural changes expected in the product and the related industry structure during this time period are also described.

- Scenario II represents the effects of proposed changes in Federal Government product specifications considering only that portion of the output purchased by the Government. Here we discuss whether we believe industry will comply with the new specifications, and our estimate of what the degree of compliance will be.

- Scenario III represents the effect of a combination of tactics that includes a change in Government purchasing

> policy, the "ripple" effect, and other economic incentives. This scenario represents the ultimate effect that could be expected. Technology provides the ultimate boundary conditions, but this scenario also indicates the economic boundary condition and the nature of the economic factors involved.

To the extent possible, considering the lack of information and the budgetary constraints, we have assessed the economic effects that would be expected under the three scenario conditions on the industry that is the primary producer of the selected product. This scenario treatment was used for each product selected as a solid waste reduction opportunity in the material categories--paper, glass, metal, and rubber. If more than one strategy was included for the selected product, more than one scenario treatment was used.

Under Scenarios II and III, industry responses will be varied over time (subject to a probability distribution), rather than perfectly predictable (deterministic), especially over such an impact analysis period spanning more than a decade. Consequently, the statement of the long-term effects in each case are, at best, plausible ranges and only define the outer impact limits--quantitatively when possible or qualitatively when quantitative extrapolations could not be made with some degree of confidence.

II. PAPER AND PAPERBOARD

AN OVERVIEW

Recycling in the pulp and paper industry has been reviewed extensively in recent studies sponsored by both the EPA[4] and private industry.[5] Based in large part on these and other publications, we will give a brief overivew of the pulp and paper industry and, in particular, the secondary fiber industry.

Technology

About 80 percent of the fiber used in the manufacture of paper and paperboard is derived from virgin wood pulp, and the remainder from secondary or reused fiber. Virgin pulp is made predominantly from wood--either by mechanical processing, chemical treatments, or combinations of both. Pulp obtained by grinding whole wood (mechanical processing) is called groundwood pulp. In this process, the fibers are cut extensively; most of the wood components remain in the pulp, including lignin, which cements the fibers together. The presence of lignin reduces the strength of the pulp and causes it to yellow rapidly in sunlight. Therefore, this pulp is generally used in the weaker, less permanent papers such as newsprint, magazines, and other paper products not designed for long-term use.

Most chemical pulp is made by the Kraft process in which wood chips are cooked with a solution of sodium hydroxide and sodium sulfide. At present, approximately 70 percent of all pulp made in the United States is Kraft pulp. It is used in unbleached products such as linerboard and bag paper, where strength is required, and in bleached form in printing papers, food board, etc. Another chemical process for producing pulp is the sulfite process. Here, chips of coniferous wood such as spruce, pine, and hemlock are "cooked" in solutions of sulfurous acid and bases such as calcium, sodium, magnesium, or ammonium hydroxide.

Most of the growth in chemical pulping in the past 20 to 30 years has been in Kraft pulping, because in this process the recovery system for the cooking chemicals is economic and efficient. Until recently, an equivalent recovery system was not available for sulfite pulping. Moreover, Kraft pulp is also stronger than sulfite pulp, and the process is applicable to almost all woods.

The third major pulping process is the neutral sulfite semichemical (NSSC) process, where wood chips are treated with a chemical and then subjected to mechanical disintegration to produce a pulp. At present, this process is used principally in the manufacture of corrugating medium.

All of the pulps, especially Kraft and sulfite, can be made with a wide range of physical properties. Pulping conditions as well as the wood species (e.g., hardwood or softwood) can be varied to achieve differences in product quality. The papermaker uses one or more of these pulps to achieve specific physical properties in the final product. In addition, he can use secondary fiber (S.F.) derived from waste paper as an additional type of pulp. Secondary fiber also can provide the papermaker with a wide variety of physical properties and can be blended with other pulps to achieve desired end-product characteristics, including low cost.

Industry Structure

The U.S. pulp and paper industry (excluding independent converting operations), consists of approximately 385 companies operating about 800 manufacturing establishments. Of these, about 120 establishments are in New England, 133 in the Middle Atlantic region, 156 in the East North Central region, 21 in the West North Central region, 69 in the South Atlantic area, 46 in the East South Central region, 44 in the West South Central region, and 84 in the West. Currently, about 50 percent of the total tonnage of paper and paperboard products is produced in the South, 15 percent in the West, and the balance split between the Northeast and Midwestern regions.

Of the 385 companies in the industry, the top 20 account for 65 to 70 percent of the pulp, paper and paperboard shipments, based on value; the top 50 firms account for 90 percent. These companies are typically integrated to pulp manufacturing and have sales greater than $40 million per year.

As a result of the historical pattern of paper industry development, the older and smaller mills are located in the Northeast and North Central regions. Also, because of the relative scarcity and higher cost of pulp wood in these regions, many of the mills there rely heavily on purchased wood pulp and waste paper for their raw material. Virtually all of the mills in the South and West are integrated to pulping facilities and company-owned woodlands. Characteristically, these mills are owned by the largest companies in the industry, whereas in the Northeast and North Central regions many family-owned single-mill concerns still exist.

There are also some regional characteristics among the products produced by the industry. For example, most of the Kraft linerboard and corrugating medium used to make corrugated containers and the unbleached bag paper are produced in the South and Pacific Northwest. On the other hand, a large percentage of the coated- and fine-paper grades for printing and business operations are produced in the older paper mills of the Northeast and Midwest, many of which rely on purchased pulp and de-inked waste for raw materials. Much of the tissue paper is also manufactured in the Northeast and Midwest, principally because of the proximity to major population centers. For the most part, combination paperboard products are produced in or near urban centers, where waste fiber, the principal raw material, is easily accessible.

The large commodity producers such as the Southern Kraft paper and linerboard manufacturers are the most capital intensive sectors of industry. The small combination paperboard, tissue, and fine-paper mills in the Northeast and Midwest are more often the independent companies with relatively low net worth and limited capabilities to attract or reinvest new capital.

Historical Supply/Demand Pattern

After World War II, demand in the United States for all types of paper and board products rose from about 25 million tons in 1947 to about 57 million tons in 1970 (Table 9). Total demand is projected to increase to 105 million tons by 1985, according to the American Paper Institute (API). In the 1947 to 1970 period, production in the United States of all grades of paper and paperboard has risen from 21 million tons to 52.5 million tons (Table 10) and total production is expected to increase to about 98 million tons by 1985.

In 1970, about 7 million tons of paper was imported (primarily newsprint) and about 2 million tons of paperboard was exported. The net import balance of all types of paper and board products that year was about 4.5 million tons. The same general import/export pattern is expected to exist in 1985, with 11 million tons of import paper and 4 million tons of export paperboard. The net import balance will then be about 7.4 million tons of all types of paper and board products.

Sources of Fiber

Wood pulp and secondary fiber, which is derived from waste paper, are the primary raw materials for producing paper and paperboard (Table 11). The consumption of secondary fiber (S.F.) in the United States grew about 50 percent between 1947 and 1970, while

TABLE 9

DEMAND FOR PAPER AND PAPERBOARD
(THOUSAND TONS)

	Real G.N.P. per billion $	Paper consumption	Paperboard consumption	Wet machine board consumption	Construction paper and paperboard consumption	Total paper and board consumption
1947	309.9	13,167	9,100	150†	2,333	24,749
1950	355.3	15,333	10,868	163	2,647	29,012
1955	438.0	17,698	13,582	179	3,260	34,719
1960	437.8	20,546	15,150	177	3,266	39,138
1965	617.8	25,152	19,670	150	4,130	49,102
1970‡	720.0	29,649	22,789	163	4,280	56,881
1975§	909.0	37,269	29,088	182	5,712	72,251
1980§	1,100.0	45,100	35,200	200	6,845	87,345
1985§	1,330.0	54,260	42,300	215	8,300	105,075

Source: Bureau of Census, Department of Commerce

† Estimate.

‡ Preliminary and forecast.

§ Forecast by Economics Department, American Paper Institute.

TABLE 10

PAPER AND PAPERBOARD PRODUCTS: IMPORTS, EXPORTS AND NEW SUPPLY (THOUSAND TONS)

	Production	Imports	Exports	New supply
1947	21,102	4,122	474	24,749
1950	24,375	5,008	372	29,012
1955	30,178	5,386	845	34,719
1960	34 444	5,721	1,027	39,138
1965	44,080	6,800	1,778	49,102
1970†	52,457	7,268	2,843	56,881
1971‡	54,304	7,325	2,780	58,849
1972‡	57,375	7,660	2,880	62,155
1975‡	67,211	8,320	3,400	72,251
1980‡	81,370	10,200	4,225	87,345
1985‡	97,675	+7,400		105,075

Source: Bureau of Census, Department of Commerce

† Preliminary and forecast.

‡ Forecast by Economics Department, American Paper Institute.

TABLE 11

FIBER REQUIREMENTS FOR PRODUCTION OF PAPER AND PAPERBOARD
(THOUSAND TONS)

	Paper and paperboard production	Supply of fiber for production				% Waste paper in production
		Waste paper	Other pulp	Wood pulp	Total fibers	
1947	21,102	8,009	1,526	13,493	22,788	37.9
1950	24,375	7,956	1,439	16,440	25,904	32.7
1955	30,178	9,041	1,340	21,315	31,835	29.9
1960	34,444	9,031	971	25,594	35,596	26.3
1965	44,080	10,231	879	34,437	45,547	23.2
1970	52,600	12,000†	867	42,500‡	55,367	22.8

Source: Bureau of Census, Department of Commerce

† Estimate by the Institute of Paper Chemistry.

‡ Estimated by Economics Department, American Paper Institute.

the consumption of wood pulp grew about 320 percent during the same period. The use of other pulps (rag, cotton, straw, bagasse, etc.) was minor and has decreased in importance over the years. Expressed as a percentage of total fiber consumption, S.F. has declined in importance in the United States. In 1947, S.F. accounted for 37.6 percent of the total fiber consumed but only 22.8 percent in 1970.

Furthermore, a remarkable shift in the source of wood for wood pulp occurred in the post-World War II years. In 1945, for example, roundwood or pulpwood in whole log form was used for most wood pulp production; whereas in 1970, residue wood (i.e., wastewood from some milling operations in the form of slabs, edgings, and sawdust) accounted for 28 percent of the total wood pulp used in the manufacture of paper and paperboard in the United States (Table 12). Thus, in a sense, close to 45 percent of the fiber used in 1970 to manufacture paper and paperboard was waste fiber derived from either wastepaper or wastewood. Before wastewood was used for pulping (and for the manufacture of other forest products, such as particleboard, fiberboard, etc.), it was either burned or left to decay. In either case, it represented a source of pollution.

There are, however, important differences between wastepaper and wastewood. The paper often is post-consumer waste, while the wood is essentially virgin material, because it was never truly processed. In fact, residue wood is an extremely economic source of fiber for the pulp industry. In most cases, the pulp obtained from residue wood is indistinguishable in quality from the pulp made from roundwood. Recently, a strong trend has developed to install complete wood conversion complexes, where the logs are fed into a manufacturing facility and utilized for the highest value products. Quite frequently, in such an installation most of the pulpwood comes from slabs, edgings, and sawdust, and the solid wood goes to plywood, lumber, and other higher-value products.

Today, over 70 percent of the pulp produced on the West Coast is made from such wood wastes and over 25 percent of the pulp produced in the Southeast comes from similar sources. Softwood sawdust is used to make a hardwood-like pulp, and pulp from agricultural residues such as bagasse can be used interchangeably with many hardwood pulps. In contrast, S.F. derived from paper sources must be recovered from the field, de-fibered, and cleaned of contaminants. In general, these recovered fibers are not as strong as virgin pulp fibers and, unless they are extensively cleaned and bleached they are not as bright or as clean as virgin pulp.

TABLE 12

CONSUMPTION OF FIBROUS RAW MATERIAL IN PAPER AND PAPERBOARD MANUFACTURE (THOUSAND TONS)

Year	Total	From roundwood	From residues	% residue
1947	10,825	10,533	292	3
1950	16,509	15,634	875	5
1955	21,454	19,738	1,716	8
1960	25,700	20,997	4,703	18
1965	34,006	25,368	8,638	25
1970	42,500	30,600	11,900	28

Source: Bureau of the Census, Department of Commerce. Estimate by the Institute of Paper Chemistry.

Present Recycling Practices

Wastepaper is the source of S.F. in the paper industry. In general, wastepaper consists of discarded paper or paperboard, and once collected, sorted, and put into a reuseable form is often called paper stock. The term secondary fiber (S.F.) used in this report applies to fibers that have been used more than once in papermaking; virgin fibers are those that have never been used for papermaking.

The overall pattern of fiber usage, and the ultimate disposition of the fibers in the U.S. is summarized in Figure 1 which illustrates that commercial and industrial paper trash contribute almost as much as household trash to the total paper waste stream.

Secondary fibers can be classified according to their origin as:

1. Converter waste, not printed or otherwise contaminated.
2. Converter waste, printed or combined with foreign materials (e.g., plastic films, hot melt adhesives, lattices, etc.)
3. Post-consumer waste
    a. Industrial fibrous waste collected from factories, stores, office buildings, etc.
    b. Fibrous wastes collected from private homes.
    c. Fibrous wastes collected from municipal refuse.

Reject paper generated at the papermaking machine or during an associated converting operation and recycled directly by the paper producer or converter without substantial additional treatment is called "broke" by the industry and is considered primary or virgin fiber, according to our definition.

The above definition of secondary fibers is based on the origin of the waste and says little about its quality or how it may be reused. Over 45 distinct paper stock grades have been identified by the Paper Stock Institute of America, but Dr. Slatin (economist and statistician) of API and several others generally consider only five grades. These include most secondary fiber sources of commercial value and are as follows:

1. Mixed - mixtures of various qualities of paper generally collected from office buildings, etc.

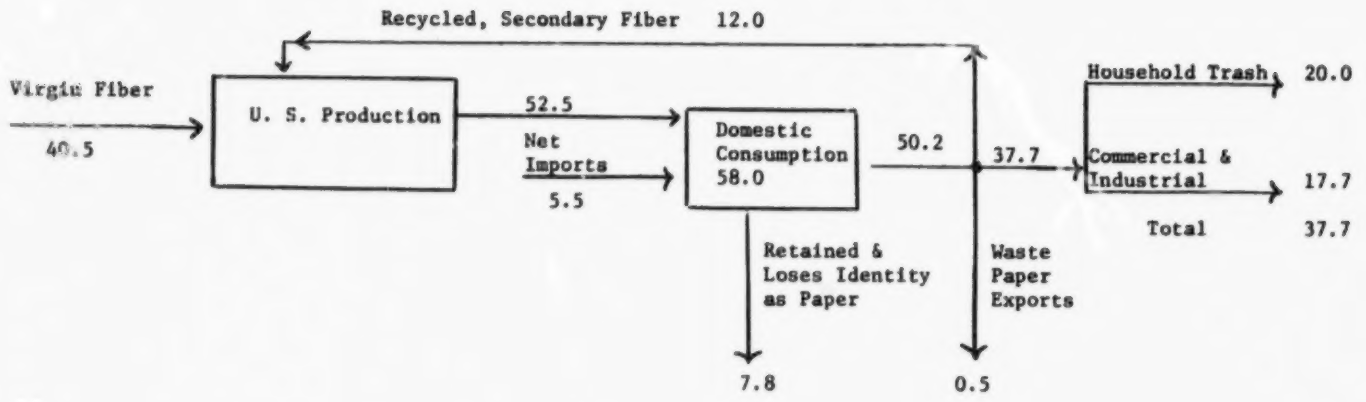

FIGURE 1. U.S. PULP AND PAPER FIBER BALANCE 1970 IN MILLIONS OF SHORT TONS.

Source: U. S. Department of Commerce
and Arthur D. Little, Inc., estimates

2. News - self explanatory.

3. Container - used boxes, generally collected from stores, supermarkets, etc.

4. Pulp substitutes - clean secondary fiber which can be used in the papermaking process without substantial additional treatment.

5. De-inking - high-grade printed stock which requires cleaning and de-inking prior to use, generally in bleached grades.

The two major end uses for secondary fibers are boxboard and shipping containers (Table 13). These two uses, together with packaging and industrial converting, account for over two-thirds of the total volume of secondary fiber consumed in the United States. Construction paper is another large market for S.F. This market and that for printing and tissue consume most of the remaining tonnage.

A recent study completed for EPA[6] shows that about 40 percent of the total secondary fiber utilized in the United States comes from the converting operations and thus is not post-consumer waste (Table 14 and Figure 2). Much of this is clean secondary fiber (pulp substitutes) which frequently can be recycled in the papermaking process without additional processing. Clippings from bag, carton, or container manufacturing are examples of such waste. Of the post-consumer waste utilized in production, about three-quarters comes from commercial and business sources and only one-quarter from private consumer sources.

Technical Limitations in the Use of Secondary Fiber

To estimate the total quantity of S.F. that can be used to manufacture paper and paperboard, one must consider the limitations of S.F. quality. First, when pulp or paper is dried, an irreversible loss in strength occurs. Thus, a dried pulp does not give the same exact product as a never-dried pulp. Secondly, in repetitive repulping of dried paper, some physical properties change. For example, burst strength decreases by about 30 percent, when paper is repulped six times; tensile strength decreases by about 25 percent; bulk increases somewhat; tear strength increases; and average fiber length decreases. The increase in tear strength is due to the decrease in tensile strength and, if the fiber were given additional beatings to obtain the same tensile strength as virgin paper, tear strength would be lower. However, one can compensate

TABLE 13

CONSUMPTION OF SECONDARY FIBER IN THE U.S. (1969)

Grade of secondary fiber	Consumption Thousand tons	Largest application	Thousand tons	% of total	Second largest application	Thousand tons	% of total
Mixed	2,649	boxboard	1,300	49	construction	695	26
News	2,163	boxboard	1,050	49	printing	368	17
Container	4,444	shipping container	1,665	38	boxboard	1,336	30
Pulp Substitutes	1,958	boxboard	716	37	tissue	501	26
De-inking	760	tissue	290	38	printing	218	29
Total	11,974	-----	-----	--	-----	---	--

Source: McClenahan, W. S., "Consumption of Paper Stock by U.S. Mills," in Proceedings: Fourth Secondary Fiber Conference, San Francisco, Calif., September 1971

TABLE 14

PATTERN OF SECONDARY FIBER GENERATION AND USE IN U.S. PAPER & BOARD INDUSTRY (1967)†

Primary			Conversion‡			End use			Final disposition	
Type	Production, 000 tons	Consumption of S.F., 000 tons	Type	Production, 000 tons	S.F. generation 000 tons	Type	Consumption 000 tons	S.F. generation 000 tons	Type	000 tons
Paper	20,656	1,354	Printing & publ.	13,831	1,045	Consumer	23,380	1,680	Delayed in discard as waste	1,303
Paperboard	22,348	8,000	Conv. & Pkg.	12,088	1,210	Commercial, business, etc.	20,164	4,410	Permanently retained, etc.	6,798
Building paper and board	3,849	728	Board pkg.	16,830	1,955	Industrial	2,537	0	Discarded as waste domestic	20,156
Imports	7,676	86	Industrial	2,337	0	Construction	4,092	0		
Exports	-1,966	-262	Construction	4,092	0				Commercial and industrial	15,826
TOTAL	51,963	9,906		49,073	4,210		50,173	6,290		44,083

Source: Reference 6

† Midwest Research indicates that the inventory buildup is not considered in these statistics

‡ Tonnage includes ink, wax, foil, plastic, etc., in addition to paper and paperboard used in the converting operation

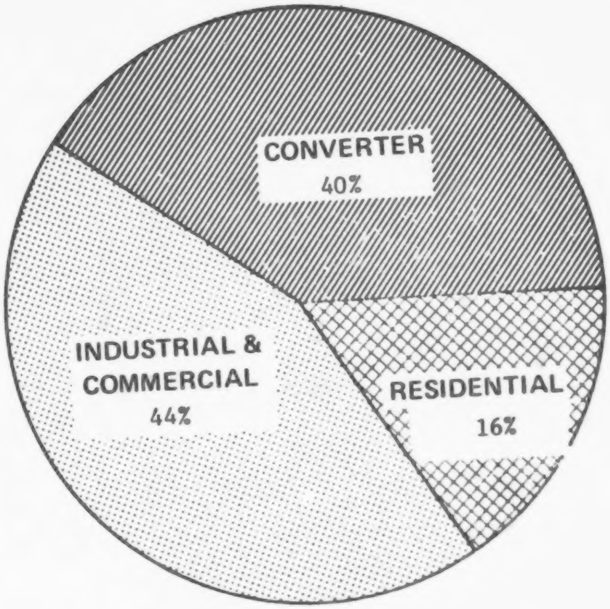

FIGURE 2. SOURCES OF SECONDARY FIBER
(from Reference 6)

for the lower burst and tensile strengths by increasing the degree of beating, using additives, and other approaches. Some of the properties are improved. For example, the increased bulk and increased opacity of paper made from S.F. are desirable properties. Therefore, repulped paper properties are useful in such products as printing and tissue papers, which can tolerate the decrease in strength and benefit from the increase in bulk and opacity.

If the secondary fiber must be de-inked and treated to remove other contaminants, further changes take place in the physical properties of the fiber. Usually, caustic solutions are used in this processing of secondary fiber. This results in a further lowering of tensile and burst strength, and a further increase in the bulk and opacity of the paper product.

In the secondary fiber treating process, one or more washing stages are used; these generally remove the fines. This is undesirable in products such as newsprint, because fines contribute to opacity and printability. Also, with the additional repulping and reprocessing, the fiber length of the resulting secondary fiber is further reduced.

Another factor associated with the quality of secondary fiber is contaminants. Such materials may be present in concentrations as low as five parts per million and still cause the complete rejection of the pulp. For example, adhesives or other sticky resins plug the wire and felts, melt on the heated drums, and adhere to the paper, etc., during the manufacturing process. These and other contaminants such as dirt reduce the desirability of using secondary fiber, particularly in the production of high-quality bleached products and in high-speed, large-volume machines, where the above contaminants can cause frequent shutdowns that more than offset the savings obtained by using secondary fiber.

As a first step in estimating the percentage of S.F. that might be utilized in the various paper and paperboard products, we considered the maximum quantity of secondary fiber that could be used based solely on the technical requirements of the product. We assumed that the optimum secondary fiber de-inking and treating processes were utilized and that the product should match or exceed the physical properties obtained with an all-virgin pulp furnish. We also assumed that a higher basis weight (the basis weight is the weight of a unit area of sheet) could be utilized to obtain the desired physical properties. But, in our estimates we did not consider the effect of strength additives (Table 15). Our conclusions are summarized below.

TABLE 15

SECONDARY FIBER USAGE: PRESENT AND TECHNICALLY FEASIBLE LEVEL

Paper or board product	SIC Code	1969 Level of S.F. use, %†				Total	Technically achievable level of S.F. use, %†				Total
		1	2	3	4		1	2	3	4	
Newsprint	2621100	-	11	-	-	11	-	100	-	-	100
Printing, writing & related	26212-26216	7	-	-	-	7	50	20	-	10	80
Packaging, and industrial converting paper	26217-26218	6	<1	<1	<1	<9	25	-	25	-	50
Special industrial	26219	9	-	<1	-	<10	30	-	30	-	60
Tissue	26210	25	<1	2	<1	<29	80	20	-	-	100
Boxboard	26314-26316	16	18	23	23	80	20	20	30	30	100
Linerboard	26311	<1	-	3	-	<4	20	-	50	-	70
Corrugating medium	26313	-	-	20	-	20	30	-	70	-	100
Special combination packaging and converting board	26317	4	6	13	6	29	5	30	30	25	90
Bleached packaging and industrial converting board	26312	-	-	-	-	--	30	-	-	-	30
Construction	26612	-	12	12	43	67	-	20	20	60	100
Wet Machine	26318	6	-	6	50	62	15	10	15	60	100

Source: McClenahan, W.S., "Consumption of Paper Stock by U.S. Mills," in Proceedings: Fourth Secondary Fiber Conference, San Francisco, Calif., September 1971, Ref. 6.
Arthur D. Little estimates.

†Paper stock grades: (1) Pulp substitutes and deinking; (2) News; (3) Container; (4) Mixed

Newsprint is currently manufactured from 100 percent secondary fiber; therefore, this is the technically achievable level for the use of secondary fiber in newsprint.

Printing and writing papers of high quality are being produced with a content of approximately 100 percent secondary fiber by some companies such as Bergstrom. Thus, a technically achievable goal to produce these papers with 80 percent secondary fiber is reasonable. Most of this S.F. would come from pulp substitutes or de-inked fiber, with lesser quantities derived from de-inked news and mixed-paper grades.

Packaging and industrial converting paper require adequate strength properties. Thus, the degradation of strength properties in the repulping and recovery of secondary fiber is a technical constraint in the use of S.F. in these products. We project a maximum usage of 50 percent S.F. in such furnishes--about one-half derived from pulp substitutes or de-inked fiber for use in bleached grades, and about one-half from unbleached containerboard waste.

Special industrial products also require high strength although some of these products may not need the strength of the previous category. Therefore, we assume 60 percent secondary fiber utilization may be attainable in this category.

Tissues of high-quality are presently being manufactured with 100 percent secondary fiber by such companies as Erving Paper Mills (Erving, Mass.). Thus, we can assume that it is technically feasible to make tissues with 100 percent secondary fiber furnish.

Boxboard is made largely from secondary fiber today (80 percent in 1969). Some virgin fiber is used for the top liner stock, but we see no reason why boxboard could not be produced from 100 percent S.F. The present secondary fiber mix used as furnish is based on an approximately equal contribution from the four major paper stock grades--pulp substitutes and de-inked fiber, news, containerboard, and mixed papers.

Linerboard requires some strength properties, especially burst and stiffness. While this represents a technical constraint upon the use of secondary fiber, nevertheless some mills today utilize large quantities of waste for linerboard. (This is often called "jute".) In many instances, deficiencies in physical properties due to the presence of S.F. are compensated for either by using a somewhat higher base weight than that for board manufactured from virgin pulp, or by using strength additives. Without additives, we assume that an acceptable linerboard product could be made from a furnish with 20 percent pulp substitute secondary fiber and 50 percent S.F. from used corrugated containers.

Corrugating medium requires stiffness. Today, some mills produce corrugating medium from 100 percent secondary fiber ("bogus"). Thus, from a technical point of view, we assume that it would be possible to produce an acceptable corrugating medium with 100 percent S.F.

Special combination packaging and converting board can use a high concentration of secondary fiber as furnish. We estimate that a broad range of products in this category could be produced with 90 percent secondary fiber (predominantly from used corrugated cases) and perhaps only 10 percent virgin pulp.

Bleached packaging and industrial converting board grades are predominantly solid bleached virgin sulfate pulp and must meet FDA requirements. Therefore, use of consumer waste in this category is limited, especially if the packaging is in contact with food--particularly wet foods or liquids. However, some clean converter waste or indeed bleached stock may be used in such applications. In addition, multi-ply structures with virgin pulp on the surface and S.F. in the interior could be used. We estimate that about 30 percent of the virgin pulp could be replaced with secondary fibers. Most or all of this S.F. would be used as a facing stock in multi-ply food-board sheet.

Packaging and industrial converting board includes both bleached foodboard and unbleached industrial specialties. Secondary fiber could be considered as the furnish for a major portion of the unbleached industrial specialty products, but the bleached food packaging products present the same problem discussed above. We estimate that the replacement of virgin pulp with 50 percent secondary fibers is technically achievable. Most of the S.F. would come from unbleached and semi-bleached converting board.

Construction paper and board and wet-machine board today are made with a high concentration of secondary fiber. We see no reason why 100 percent secondary fiber could not be utilized in both grades.

If carried to the logical extreme, the estimates given in Table 15 indicate that if (1) waste paper and paperboard could be collected in the proper form, (2) in the right geographical area, (3) and non-polluting facilities for reprocessing were available, (4) and the economics were favorable, it would be possible to recycle most of the paper going into the solid waste stream. But, this includes many "ifs." Consequently, the estimates of practical achievable levels of S.F. utilization must be revised when these other factors are considered. In this report, we will consider these factors for one of the important paper commodities. A complete discussion of all paper products is beyond the scope of this study.

The Influence of Geography on Secondary Fiber Consumption and Supply

Most S.F. is consumed in the East and East-North-Central population centers (Table 16). Overall, about 20 percent of the paper and paperboard was recycled in the United States in 1970 but, as indicated by the table, recycling varied with geography. The exact geographic distribution of S.F. consumption is difficult to ascertain, because shipments from one geographic area to another frequently occur, especially in the case of higher-value pulp-substitute S.F. However, by using the average per-capita consumption of paper and paperboard by grade to estimate the consumption in each geographic area (and making some adjustments, as in the case of printing and writing papers, where it is recognized that the printing industry has large concentrations in the Chicago and Philadelphia areas), we have estimated the potential supply of wastepaper or paper stock on a regional basis (Table 17).

In this table, we have computed the initial supply of paperstock based on consumption statistics and subtracted the estimated volumes recycled in each region to arrive at an estimate of the volume of paperstock remaining in the solid waste stream. Note that the rate of recycling varies from 39 percent in the East North Central to 8 percent in the West North Central region. In

TABLE 16

ESTIMATED CONSUMPTION OF SECONDARY FIBER BY GRADE IN THE U.S. (1970)

	Total		Mixed papers		Newspapers		Corrugated		Pulp substitute and high-grade de-inking	
	(000's ton)	(%)	(000's ton)	(%)	(000's ton)	(%)	(000's ton)	(%)	(000's ton)	(%)
New England	1,093	100	172	15.8	144	13.2	301	27.5	476	43.4
Middle Atlantic	2,805	100	606	21.6	617	22.0	816	29.1	766	27.3
South Atlantic	1,188	100	255	21.5	169	14.2	557	46.9	207	17.4
East North Central	4,053	100	837	20.7	739	18.2	1,311	32.3	1,166	28.8
West North Central	352	100	105	29.8	64	18.2	136	38.6	47	13.4
East South Central	503	100	122	24.3	71	14.1	226	44.9	84	16.7
West South Central	551	100	195	35.4	88	16.0	188	34.1	80	14.5
Washington, Oregon Mountain	338	100	79	23.4	50	14.8	158	46.7	51	15.1
California	1,138	100	268	23.6	293	25.7	387	34.0	190	16.7
TOTAL U.S. (Tons)	12,021		2,639	22.0	2,235	18.6	4,080	33.9	3,067	25.5

Sources: Arthur D. Little, Inc., and A.P.I. estimates

TABLE 17

POTENTIAL SUPPLY OF PAPER STOCK BY GEOGRAPHICAL REGION (1970)

(thousands of tons)

Region	Initial supply[†]	Supply recycled	Percent recycled	Supply not recycled[‡]
New England	3,072	1,093	36	1,979
Middle Atlantic	9,958	2,805	28	7,153
South Atlantic	7,713	1,188	15	6,525
East South Central	3,223	503	16	2,720
West South Central	4,818	551	11	4,267
East North Central	10,488	4,053	39	6,435
West North Central	4,155	352	8	3,803
Washington, Oregon and Mountain States	3,475	338	10	3,137
California	5,084	1,138	22	3,946
Total	51,986	12,021		39,965

Source: Arthur D. Little, Inc., estimates

[†] Values were obtained by subtracting the unrecoverable paper and paperboard (See section "Secondary Fiber Supply.")

[‡] Presently in the solid waste stream.

spite of the higher rate of recycling in the more populated areas, the supply of paper stock that is not recycled and is presently solid waste is greatest in these same areas.

Structure of the Secondary Fiber Industry

Waste paper is collected, processed, and sold by a distinct segment of the secondary materials industry--the paper stock dealers. Some smaller dealers handle both metals and paper. Most dealers have long-standing relationships with consuming mills and operate on the basis of 30-day purchase orders. In the Far West and Southeastern parts of the United States, the "traditional" waste paper dealers and private refuse haulers compete. Refuse haulers are also becoming more of a factor in collection of waste paper in other parts of the country. In waste paper handling, as in other segments of the secondary materials industry, the trend is toward larger organizations; in some cases, groups of large paper stock consumers have also entered the market by acquiring paper stock dealers.

Most dealers prefer to do as little processing as possible. Large converters and printing plants which purchase from the dealers usually sort and bale their own paper stock; the dealer acts merely as a sales and/or transportation link between secondary-fiber generators and mills. Some small waste-paper generators, such as warehouses, have found it profitable to install small balers. With bulk grades collected from residential sources and office buildings, dealer processing is usually required. Some large dealers have high-speed, large-capacity baling systems that can cut processing costs; therefore, they can actively seek paper from generators who cannot justify in-house baling equipment.

If dealers were faced with a sudden influx of unprocessed and unbaled materials, they would probably not be able to process a large tonnage, because most of their installed capacity is old and inefficient. Only a few highly efficient handling systems are now in existence.

New Secondary Fiber Sources

A major type of potentially available secondary fiber is the waste paper and paperboard in municipal trash. This material is unrecoverable at the present time for two reasons. The paper and paperboard products are mixed and contain a variety of pulps such as groundwood, semi-chemical, unbleached, and bleached chemical pulps, as well as a variety of non-fibrous components such as plastic film, metal foil, latex adhesives, etc. In addition, the paper and paperboard products are mixed with garbage and other domestic and industrial refuse. The separation of this mixture into fractions which can be effectively and economically utilized in the paper and paperboard industry is difficult.

Two basic approaches for separating paper from municipal refuse are now being evaluated. One is the wet system, where the entire municipal trash is shredded and put through a wet separation system in which the fibrous fraction is isolated. Black Clawson Company is conducting a demonstration unit at Franklin, Ohio, based on this approach. Recovered secondary fiber material from this process is being used in roofing felts, and trials have been run by St. Regis Paper Company, where the recovered fiber has been included in bleached printing papers.

Another approach utilizes dry separation techniques and is typified by the work being done at the Forest Products Laboratory in Madison, Wisconsin. In this approach, the shredded municipal trash is put over a conveyor and the light fraction is taken off with a vacuum pickup. This is followed by dry separation and fiberizing steps to yield, ultimately, a fibrous residue which, for example, can be mixed with resins and formed into structural construction material. The dry separation approach also can be used to recover the secondary fiber as a fuel.

SELECTION OF SOLID WASTE REDUCTION OPPORTUNITIES

Initial Screening

On the basis of selection criteria B1 and B2 (Table 8) all paper and paperboard products must qualify as one of the major opportunity areas for solid waste reduction in the United States. All estimates agree that over 50 weight percent of urban solid wastes arises from paper. Furthermore, paper products are a significant portion of our economy, and indicated in the previous section (criteria A1 and A2), and every one in the United States uses paper products--both directly and indirectly (criterion A3).

But, without extensive analysis, it is difficult to single out a specific product area within the paper and paperboard industry as representing the more favorable opportunity for reducing solid wastes. In terms of volume alone, newsprint (10 million tons per year), linerboard and corrugating medium (18 million tons per year), and unbleached Kraft packaging papers (4 million tons per year) represent large tonnages of readily identifiable single products.

Importance of Government Purchases

To select a specific product area, let us consider the importance of Government purchases of paper and paperboard products (criterion A4). Data presented by the Government indicate that total Government expenditures as a percentage of domestic output for periodicals and newspapers, fiber cans, corrugated and solid fiber boxes, cardboard boxes, and sanitary paper products, coated and converted paper are generally less than one percent of the U.S. consumption of each product category (Table 18). For the purposes of this report, we have assumed that the annual Government consumption rate of paper and paperboard is about 360,000 tons, or about 0.6 percent, of the more than 58 million tons of paper and paperboard consumed in 1970.

Thus, it is not surprising that Government purchases are usually unimportant to many of the U.S. paper and paperboard companies. The total Government requirements for any single grade of paper or paperboard product could probably be met at the present time with products containing the maximum technically allowable quantity of S.F.

In addition to the purchases of paper and paperboard products, as such, the Government also purchases larger quantities of paper and paperboard as packaging, when they purchase other products. About 30 million tons of packaging paper and paperboard are consumed annually in the United States. If we assume that the Government purchases, on the average, 5 percent of the total production of this packaging material (no accurate statistics are available--our estimate is based on interviews with numerous Government procuring agencies), the Government could perhaps directly influence the purchase of 1.5 million tons of paper and paperboard. Therefore, among the paper and paperboard products, packaging products represent the more significant opportunity area for reducing solid waste.

Government purchase of packaging materials via Government specifications on packaged goods offers still additional leverage for reducing solid waste, because companies that utilize packaging materials and sell packaged products to the Government prefer to inventory a minimum number of packaging materials to fill both civilian and Government orders and thus avoid double stocking. Consequently, these companies have an incentive to use the same packaging materials for both Government and civilian orders. In addition, because these companies normally purchase packaging materials from several suppliers, Government specifications on packaging materials will tend to induce the several suppliers to

TABLE 18

GOVERNMENT EXPENDITURES FOR PAPER AND PAPERBOARD PRODUCTS AS A PERCENTAGE OF DOMESTIC OUTPUT (1970)

ADL sector No.	Commodity	Defense	Non defense	Total
3	Forestry and fishery products	neg.	(15.61)	(15.61)
34	Sawmill and planning mill products	neg.	-----	neg.
35	Wooden containers	1.08	0.01	1.09
39	Paper mills, ex. building paper	0.13	0.40	0.53
40	Paperboard mills	0.09	0.03	0.12
41	Coated and converted paper	0.32	0.21	0.53
43	Sanitary paper products	0.34	0.56	0.90
44	Cardboard boxes	0.23	0.09	0.32
45	Corrugated and solid fiber boxes	0.12	0.05	0.17
47	Fiber cans	1.12	-----	1.12
48	Newspaper	0.01	0.01	0.02
49	Periodicals	0.01	neg.	0.01
50	Book printing and publishing	1.19	(0.88)	0.31

Source: Arthur D. Little, Inc., computer model of the U.S. economy meet the new specifications. Hence, Government purchasing of these packaging materials could have a very significant multiplier or "ripple" effect beyond the purchases of the Government alone.

The opportunities for Government specifications to influence in a substantial way the reduction of solid wastes in the other two major product categories of paper and paperboard--cultural papers (printing papers, etc.) and personal papers--are more limited. For example, Government purchases of newspaper and periodicals, etc., are extremely small, as compared to the total domestic consumption (i.e., 0.01 percent in the case of newspaper). Furthermore, Government purchasing practices with regard to cultural and personal papers do not have the same opportunity to induce a multiplier effect, as in the case of packaging materials, because these papers are seldom used in combination with another commodity.

Secondary Screening

The paper and paperboard industry is made up of a number of sub-industries with widely varying characteristics. Consequently, the effectiveness and nature of changes in government purchasing practices directed at increasing recycling should be studied individually for each sub-industry before recommendations are made for each paper and paperboard product.

For example, the sanitary tissue industry is similar to the linerboard industry only because they both start with wood as a raw material. In almost every other characteristic, there is very little similarity--production facilities, marketing practices, ease of recovery of the product, recycling practices, etc.

Because the potential multiplier or "ripple" effect is greatest in the packaging field, we consider paper and paperboard in this market the most significant solid waste reduction opportunity. Here, changes in Government specifications can effectively meet the objective of this study.

The specifications for paper and paperboard used in other markets (printing papers, tissue, etc.) can be changed to require the use of S.F., as indicated above, but in these instances the extent of the "ripple" effect is difficult to estimate. We would expect that state and local government offices would follow the leadership of the Federal Government in this area, and the Government "stamp of approval" for these types of products would probably promote demand by the public at large. Institutions and large companies also may take notice of new Federal specifications for these products requiring secondary fiber and adopt a similar practice.

Another important paper product area where changes in Federal specifications can effectively reduce solid wastes is the construction field. If the developing technology and economics of processes for the conversion of mixed papers from municipal trash to structural materials prove satisfactory, new Federal specifications should be introduced to encourage the use of these new materials.

Because a complete analysis of all paper and paperboard products used in packaging is beyond the scope of this study, we have selected only one product for thorough analysis--linerboard. Other products will require a similar analysis, and we recommend that this be done.

Linerboard is used in the manufacture of combined board, where corrugating medium is sandwiched between two sheets of linerboard. The corrugating medium accounts for about 30 weight percent of the structure. The combined board is used to fabricate the familiar corrugated box or case. Today, corrugated cases represent the second largest packaging industry following only metal cans. Shipments were $3.9 billion in 1972, as compared to about $5 billion for metal cans. Between 90 and 95 percent of all packaged products use corrugated in one form or another. In 1970, about 13.3 million tons of linerboard and medium were consumed to produce over 180 billion square feet of combined board.

Linerboard can be made from S.F. derived from used corrugated cases (as discussed above). This S.F. source, which is one of the more easily collected S.F. sources, is the major post-consumer paper waste being recycled today. Nevertheless, large volumes of this waste remain available for recycling. About 35 percent of the recycled waste paper used in 1970 was derived from corrugated cases. The best revised estimates indicate that 4.6 million tons were recycled that year (as compared to an original estimate of 4.08 million tons made by API in 1970). We believe that about 1.8 million tons of this was converter waste and the remainder (2.8 million tons) was post-consumer waste.

As a portion of the total U.S. paper and paperboard post-consumer waste, used corrugated cases account for about 45 percent. In 1970, about 21 percent of all used corrugated cases was recovered and recycled. If converter waste is included, the recovery rate was about 35 percent, which is somewhat higher than the rates for other paper and paperboard products. The overall industry recovery rate in 1970 was 18.5 percent of all paper and paperboard consumed.

Alternative Ways of Changing Specifications

In addition to specifying the use of a certain percentage of S.F. in paper and paperboard products, a number of other possible approaches exist. One possibility is to specify a lighter weight product that meets the necessary performance characteristics. For example, the weight of the linerboard could be reduced and chemicals or other materials could be added to make up for the loss in physical properties. Another possibility is to specify the product for multiple use. Paper and paperboard products are essentially disposable (with the exception of books, permanent records, and construction board), and products are normally designed for one use with economics structured around this concept. However, it might be possible, for example, to specify special corrugated cases for use in Government warehouses that could be returned to the shipper for further use. However, when this possibility was suggested to the industries involved, they pointed out that any damage to the product arising from a contaminated or damaged case, even if it occurred once every fifty times, would more than wipe out any possible savings. In addition, the extra labor requirements for handling, sorting, cleaning, reforming, etc., would increase costs. A third approach would be to specify that the product be more recyclable. This can include a variety of actions such as specifying the use of water-soluble resins rather than water-insensitive materials. However, the paper and board industry and the consumer industries are already actively pursuing these goals; therefore, this type of governmental action would have a minimum effect.

Current Program to Change GSA Specifications for Paper and Paperboard Products

Many of the GSA specifications on paper and paperboard products are material specifications that call for the use of virgin fiber; however, in the current program GSA is changing these specifications to call for the use of secondary fiber, as indicated in Section I.

GSA has used the term "reclaimed fibers" in its specifications and has divided these fibers into two groups: (1) essentially post-consumer waste; and (2) other reclaimed fibers. Group 2 fibers include converter waste (such as envelope cuttings, carton clippings, etc.) and fibrous by-products of harvesting and manufacturing operations (e.g., slabs, edgings, and sawdust from sawmilling operations). GSA specifications on individual paper products generally require a minimum percent of reclaimed fiber which can be made up from (1) or (2) sources or both. (See Exhibit B-2.)

However, we believe that most of the converter wastes are already being utilized and, therefore, inclusion of these wastes in the GSA specification will do little to reduce solid wastes. Exceptions would be those converter wastes that are so heavily contaminated during the converting process that cleaning and de-inking become impractical; for example, waste from a printing sheet which was heavily loaded with pigments, heavily coated with a latex binder, and then color printed.

We also believe that including sawmill wastes as reclaimed fibers similarly obscures the major issue--to reduce the quantity of paper solid waste arising from post-consumer materials. Sawmill wastes are utilized now to maximum advantage in most cases, so there is little need to encourage the use of these materials via Government specifications. On the other hand, post-consumer paper waste adds about 40 million tons per year to the solid waste load in the United States; therefore, these wastes should be the primary focus of any Government attempt to reduce the solid waste arising from the paper and paperboard industry.

LINERBOARD--BASE LINE FORECAST

The present linerboard industry had its origin in the development of an economic recovery process for Kraft pulping in the late 1920's. Southern Pines and West Coast Douglas Fir could be processed by the Kraft process, whereas these species could not be handled by the sulfite process, the only chemical pulping process generally used prior to the development of Kraft pulping. Virgin Kraft linerboard output has grown rapidly--from an average production of 1.5 million tons per year in the period 1930 to 1939 to 11.4 million tons in 1970.

With plentiful supplies of hitherto unexploited wood, the Kraft process was able to turn out a low-cost product with physical properties markedly superior to sulfite or secondary fiber linerboard, which had been used prior to the development of Kraft pulping. Economies of scale led to larger integrated pulp mills and paperboard machines and, at the present time 800- to 1000-ton-per-day units are commonplace. The average output of such units is 700 tons per day.

Characteristics of the Industry

Linerboard and corrugating medium are conventionally shipped in roll form from large mills to smaller box plants located near the marketplace and then converted to combined board and corrugated boxes. In the late 1950's and early 1960's a period of forward integration occurred, and many of the independent box plants were acquired by the large linerboard producers. At the present time, over 85 percent of the boxes are made in box plants integrated back to the linerboard operation, and there are no independent converters of any significant size. The linerboard industry today is dominated by a few large producers. In 1970 about 63 percent of the linerboard was produced by the six top companies. One of the reasons this industry is dominated by a few large suppliers is that the economic size unit for virgin Kraft linerboard products is extremely large, and the capital requirements for a single mill are huge--over $100 million.

Not only are the virgin Kraft linerboard producers integrated forward, but essentially all of them have their own pulp mills and woodlands. Normally, about 50 percent of the pulpwood is supplied from the linerboard producer's woodlands. Consequently, these large linerboard producers have extensive investments in various sectors of the paper industry.

The annual U.S. production of linerboard from S.F. has remained small. In 1970, only about 350,000 tons of linerboard were made from secondary fiber, or approximately 3 percent of the total U.S. linerboard production. In the early days, when some linerboard was made with a portion of defibered and chopped burlap bags it was called "jute linerboard." The name has remained, and many people refer to any secondary fiber linerboard as jute linerboard. For lack of a better term, we often call secondary fiber linerboard "jute linerboard" in this report.

The Whippany Company (Garfield, New Jersey) is an example of a company that makes a linerboard largely from secondary fiber. It sells to box plants in the New York area. According to Whippany, its linerboard competes both in quality and cost with the virgin linerboard. Recently, the Grief Company in Ohio has built and started up a linerboard machine using secondary fiber. This represents a backward integration step for the Grief Company, because it manufactures containers utilizing linerboard.

Market Trends

Over the past ten years, linerboard production has generally had more rapid growth than real GNP--production essentially doubled (Table 19). This growth occurred because during this period linerboard has taken over a greater share of the packaging market, particularly that share satisfied by wooden crates. This process is now complete; therefore, in the future we expect that growth in this industry will roughly parallel the overall real growth in the economy.

TABLE 19

LINERBOARD PRODUCTION AND VALUE (1961-1985)[†]

	Production (million tons)	Price Index (1967 = 100)	Value ($ million)
1962	6.4	98.1	763.5
1962	6.8	97.8	809.2
1963	7.1	100.1	864.8
1964	7.9	103.3	933.0
1965	8.5	103.3	1,068.5
1966	9.5	103.3	1,194.1
1967	9.4	100.0	1,143.0
1968	10.6	94.5	1,217.9
1969	11.5	97.4	1,362.8
1970	11.4	99.4	1,378.3
1971	11.6	100.3	1,415.2
.	.	.	.
.	.	.	.
1985[‡]	18.0	100.3	2,196.0

Source: Quarterly industrial reports. January/April 1972, and capital and income survey, Dept. of Commerce

[†] Price in 1971 = $122/ton

[‡] Estimated on the basis of the 1971 price and 1971 dollars using Slatin's estimate for production volume (Ref. 7)

Dr. Slatin, the chief economist for the American Paper Institute and a recognized authority in the field, has recently estimated projected increases in the production and consumption of various paper and paperboard products from 1971 to 1985.[7] These projections are largely trend-line estimates, but we believe that they are satisfactory for the purposes of our study and have chosen to use them (Figure 3).

Need for New Capacity - Utilizing Slatin's projections, the total U.S. consumption of linerboard and corrugating medium should increase from about 13.3 million tons in 1970 to 21 million tons in 1985, while production should increase from about 15.3 million tons in 1970 to 24.5 million tons in 1985. The consumption of linerboard alone in the United States is projected at about 14.7 million tons in 1985, while the projected production for U.S. linerboard is about 18 million tons that same year. (The difference of 3.3 million tons between consumption and production arises from exports.) Thus, an estimated 6.4 million tons of new linerboard capacity will be needed by 1985.

At the present time there is little unused linerboard capacity. Therefore, the expected increase in demand will no doubt lead to increased linerboard prices and to reduced exports. Only as the price of linerboard goes up substantially and the return on investment (ROI) is judged adequate will new facilities be added. This will probably not occur to any major extent before the 1975-1978 period. In the meantime the increase in demand will be met mostly by the incremental expansion of the capacity of existing mills by "debottlenecking", rebuilding, and enlarging the smaller machines. Much of this will occur as a result of the normal replacement of equipment. Historically, this type of incremental expansion in the linerboard industry has accounted for an annual growth rate of 1.5 percent.

If we assume a 1.75 percent rate of expansion due to "debottlenecking" during the 1971 to 1985 period and a base of 11.4 million tons of capacity in 1970, this alone would account for 3.2 million tons of the estimated 6.4 million tons of additional capacity needed during this period. During the shorter-term period--1971 to 1978--3.6 million tons of additional capacity will be needed (Figure 3). The incremental expansion due to "debottlenecking" in this period would account for about half of this or 1.5 million tons. Therefore, opportunities for new mills, based on virgin or secondary fiber, will be about 2.1 million tons. Planning and construction of a virgin Kraft linerboard facility requires about three years, and none is under construction today. A mill using 100 percent secondary fiber as furnish would require less time for construction. As described in the section on process economics, these mills would typically be built in smaller increments.

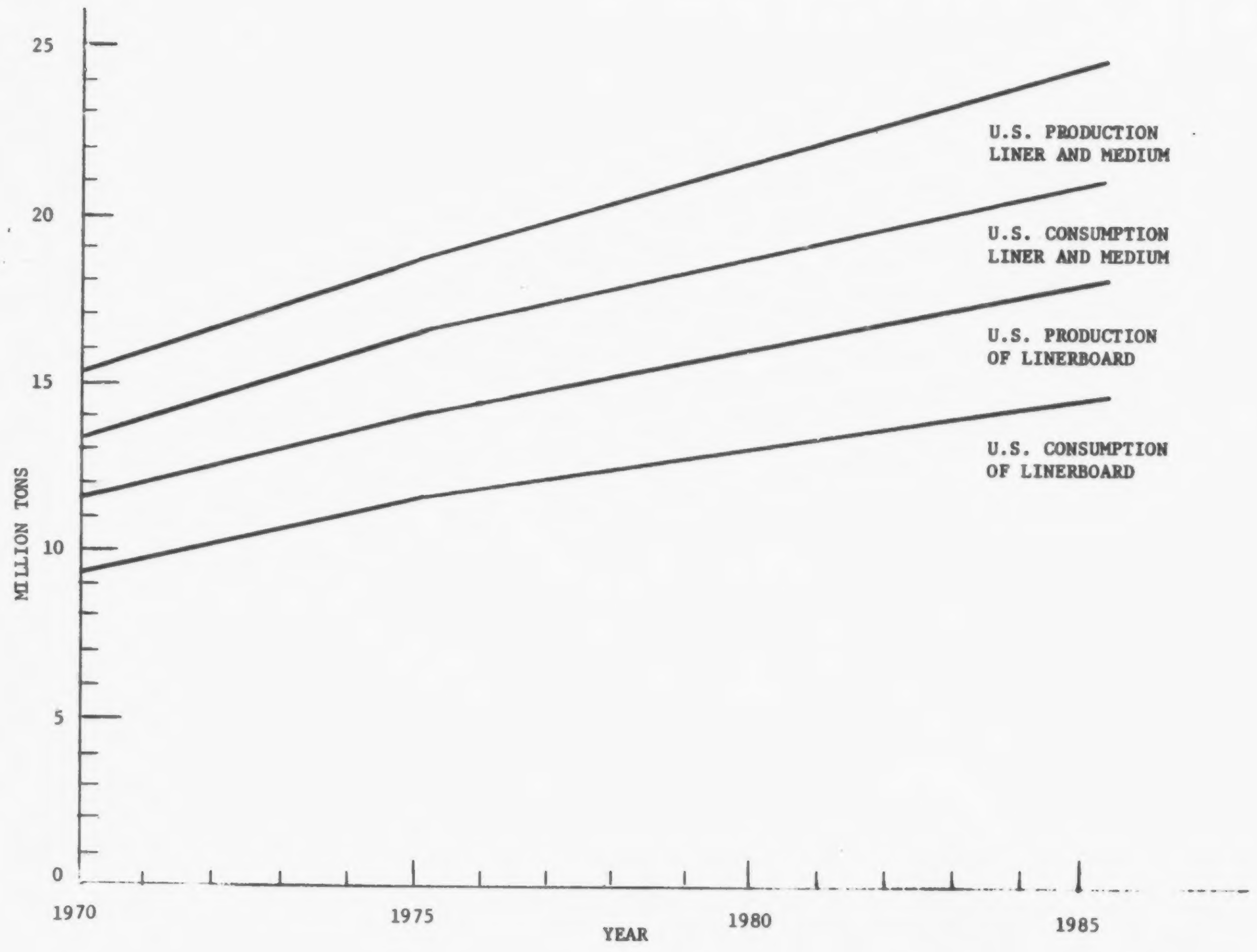

FIGURE 3. U.S. PRODUCTION AND DEMAND FOR LINERBOARD AND CORRUGATING MEDIUM (from Reference 7)

Because new investment in this industry will not occur until linerboard prices and ROI increase sufficiently, it is important to look at competitive products to determine whether the price of linerboard can increase. If the increase in price reduces the demand for linerboard, because substitute products appear, then the linerboard industry will not make the required investments. However, we do not believe this will happen. The only development offering any significant threat is plastic shrink wrap. Therefore, we expect that the ROI will increase and new capacity will be added.

Exports and Imports - The balance of trade for linerboard is very much in favor of the U.S.A. (Table 20), and this country has become the principal world export supplier of Kraft linerboard. American linerboard is sold throughout the world, but the major markets are in Europe. The European countries alone accounted for about half of the export sales. Other important markets are Latin America and Asia.

In the near term, we expect that the net tonnage of linerboard exports will be reduced, as the U.S. demand for linerboard increases, and when new capacity is added, the volume exported will again increase. In 1970, about 15 percent of the domestic output of linerboard was exported; by 1985, we expect this percentage to increase to about 18 percent.

The Secondary Fiber Market - Even if no changes are made in government purchasing practices and no recommendations are provided, we expect that the average secondary fiber content in linerboard will gradually increase in the 1972 to 1985 period because of:

- the increasing demands on the limited quantity of wood around the world;
- continuing public environmental concern which will encourage the collection and source sorting of post-consumer materials; and
- technical advances in the recovery of secondary fibers.

In the past, industry has directed most of its efforts to increasing virgin linerboard capacity. But, as the demands on existing wood supply become more severe and environmental concern increases, we can expect that improved and lower-cost techniques will be developed for processing secondary fiber in paper and paperboard manufacture. We expect, for example, that methods for separating linerboard and corrugating medium from used corrugated cases will be developed in the near future. This could result in a substantial improvement in the economics of recycling these used cases.

TABLE 20

EXPORTS AND IMPORTS OF UNBLEACHED LINERBOARD

	Exports (short tons)	($000)	Imports (short tons)	($000)
1961	470,000		10,000	
1962	445,000		19,000	
1963	517,000		21,000	
1964	765,000		8,000	
1965	905,000		5,000	
1966	1,027,000		45,000	
1967	1,174,000		6,000	
1968	1,494,000		7,000	
1969	1,693,000	198,000	2,081	418
1970	1,761,246	219,000	248	51
1971	1,965,892	237,000	9,804	1,000

* Source: Current Industrial Reports,
Quarterly Industrial Reports, Dept. of Commerce,
Bureau of Census. BOC-762-07-73

As mentioned earlier, on the average only about 3 percent of the furnish used today to manufacture linerboard is secondary fiber. Without incentives, we expect the growth in the use of secondary fiber in linerboard to be slow and probably represent only between 7 and 9 percent of the total fiber furnish by 185, well below the technical limitations. We anticipate that the growth in tons in the 1980 to 1985 period will be greater than in the 1972 to 1980 period. By 1980, we expect that the average secondary fiber content in linerboard will be about 5 percent, as compared to the present 3.0 percent; in 1985, the S.F. content could be about 7 to 8 percent (Table 21).

Taking into account that about 1.1 to 1.2 tons of paper stock derived from old corrugated cases yield one ton of linerboard,* then today (1972) about 480,000 tons of paper waste are being utilized for linerboard production annually. Our projection indicates that without incentives this consumption will increase to about 1.6 million tons per year by 1985.

Availability of Secondary Fiber - The availability of S.F. has been considered by Dr. Slatin, who assumed that about 50 percent of the total paper and paperboard consumed in the United States is essentially unrecoverable.[7] Sixty percent of the unrecoverable category includes construction paper and paperboard, sanitary tissue papers, printing and writing papers that go into archives, and flexible packaging papers that are largely unrecoverable, because they are mixed with household refuse. Another fraction (20 percent) is regarded as unrecoverable, because it is contaminated or collection channels are unavailable. He also assumed that the paper fiber is completely degraded after five recycles. Based on these assumptions, Dr. Slatin indicated that the maximum attainable level of recycling in the paper industry as a whole is 38 percent (based on the recycling of S.F.).

However, the maximum achievable level of secondary fiber usage for each individual product must be ascertained separately, because the percentage that is unrecoverable and the fiber loss during recycling, considering the quantity of secondary fiber that can be used in a given product, vary with the product.

Another problem in estimating the achievable level of S.F. usage for individual products is the required supply and demand for S.F.

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*This is the expected yield from a typical recovery system that uses asphalt dispersion. Fiber losses on the paper machine are included in this estimate.

TABLE 21

BASE-LINE FORECAST OF AVERAGE SECONDARY FIBER CONTENT OF LINERBOARD (1971-1985)

Year	Linerboard production†	Average furnish composition		
		Virgin†	S.F.†	% S.F.
1971	11.6	11.2	0.35	3.0
1973	13.0	12.5	0.47	3.6
1975	14.0	13.4	0.58	4.1
1978	15.2	14.5	0.74	4.9
1980	16.0	15.1	0.87	5.4
1982	16.8	15.8	1.04	6.2
1985	18.0	16.6	1.37	7.6

Source: Arthur D. Little, Inc., estimates

† Million tons

in other products. For example, the pulp substitute and de-inking grades of S.F. are in limited supply today, and if the technically achievable level were utilized in every paper product that could use it, there would be a gross undersupply of S.F. The yield will vary contingent upon: (1) the quality of the raw material; (2) the efficiency of the cleaning system; and (3) the quality of the board.

To determine the maximum attainable level of recycling in the linerboard industry, we first assumed that the entire paper and paperboard industry operates with the maximum field recovery level indicated by Dr. Slatin (i.e., 50 percent). But, we assumed that 75 percent of the linerboard consumed in the United States is recoverable and potentially available to the mills, because: (1) the maximum recovery level for linerboard is probably higher than that for the total industry average, (2) very little if any linerboard wastes go into the sewage system, and (3) very little is permanently withdrawn, as is the case with archival and construction paper.

We assumed that the degradation of fiber in linerboard is the same as other paper and paperboard products. Thus, based on Slatin's estimates, 20 percent of the fiber is lost in the first recycle, 25 percent in the second, 33 percent in the third, 50 percent in the fourth, and all in the fifth. Therefore, at the steady-state condition, considering the 75 percent recovery level and the technical limitations, the maximum attainable level of recycling in the linerboard industry is 55 percent. At the steady-state condition, then, 27 percent of the used corrugated cases are lost in the conversion to S.F.

Our analysis is based on recycling used corrugated containers into linerboard, but this S.F. source is in demand for other applications. For example, in 1970 when about 350,000 tons of used corrugated cases were used in the manufacture of linerboard and about 750,000 tons were used in the manufacture of corrugated medium, about 3.5 million tons of the 4.6 million tons of collected corrugated paper stock were used in other applications. Thus, this competition for used corrugated cases is an additional constraint on the availability of linerboard stock for recycling.

According to Slatin, by 1985, 21 million tons of corrugated cases will be consumed in the United States. Thus, potentially 75 percent of this, or 15.8 million tons would be recoverable at that time. In addition, if converter waste is available at the same rate as in 1970 (about 13.5% of the combined board consumed), then 2.8 million tons of this waste would become available in 1985. And, if we assume that the current non-linerboard and non-corrugated medium uses will continue at the same consumption level in 1985 as in 1970 (i.e., the consumption of combination furnish board products will remain relatively constant during this period), 3.5 million tons of used corrugated cases would be unavailable for the production of combined board in 1985. The markets for corrugated stock in applications other than combined board are not expected to grow to any extent, because many of these markets are approaching saturation. Consequently, based on this analysis, the net tonnage of available used corrugated cases would be 15.1 million tons in 1985 (Figure 4).

These cases could be used to manufacture linerboard and corrugated medium. To determine the tonnage of linerboard stock potentially recoverable, recall that linerboard is always combined with corrugating medium to make combined or corrugated board at a ratio of about 7 to 3. In our analysis we assumed that secondary fiber was used at the same level in medium as in linerboard and that the recovery rate was the same in both. One of the assumptions in our analysis was that techniques for separating the two corrugated case components would be developed. We believe the latter to be a reasonable assumption. Accordingly, after separation of the 15.1 million tons of corrugated stock, 7.7 million tons of linerboard S.F. and 2.7 million tons of corrugated medium S.F. would be available in 1985, based on a steady-state 73 percent yield for the conversion of the cases into S.F. (Figure 4). A similar analysis indicates that in 1978 the maximum supply of linerboard S.F. derived from used corrugated board would be about 6.3 million tons.

Maximum Attainable Usage of Secondary Fiber - Capacity Limitations

In an earlier section, we developed information on the maximum quantity of secondary fiber that might be used in various paper and paperboard products, if only technical limitations were considered (Table 15). In the case of linerboard, this technically attainable level is 70 percent, if no additives are used. Based on the above estimate for the linerboard market, this would require about 12.6 million tons of S.F. in 1985. However, as developed in the preceding section, the maximum supply of linerboard S.F. available in 1985 is expected to be only about 7.7 million tons. This tonnage, then, would result in a maximum recycling rate of about 35 percent due to supply limitations.

Although this volume of S.F. could be made available in the United States, a more significant constraint in this instance than the technical and supply constraints on recycling is the availability of secondary fiber linerboard manufacturing capacity. Earlier we indicated that in the period 1971 to 1985 opportunities

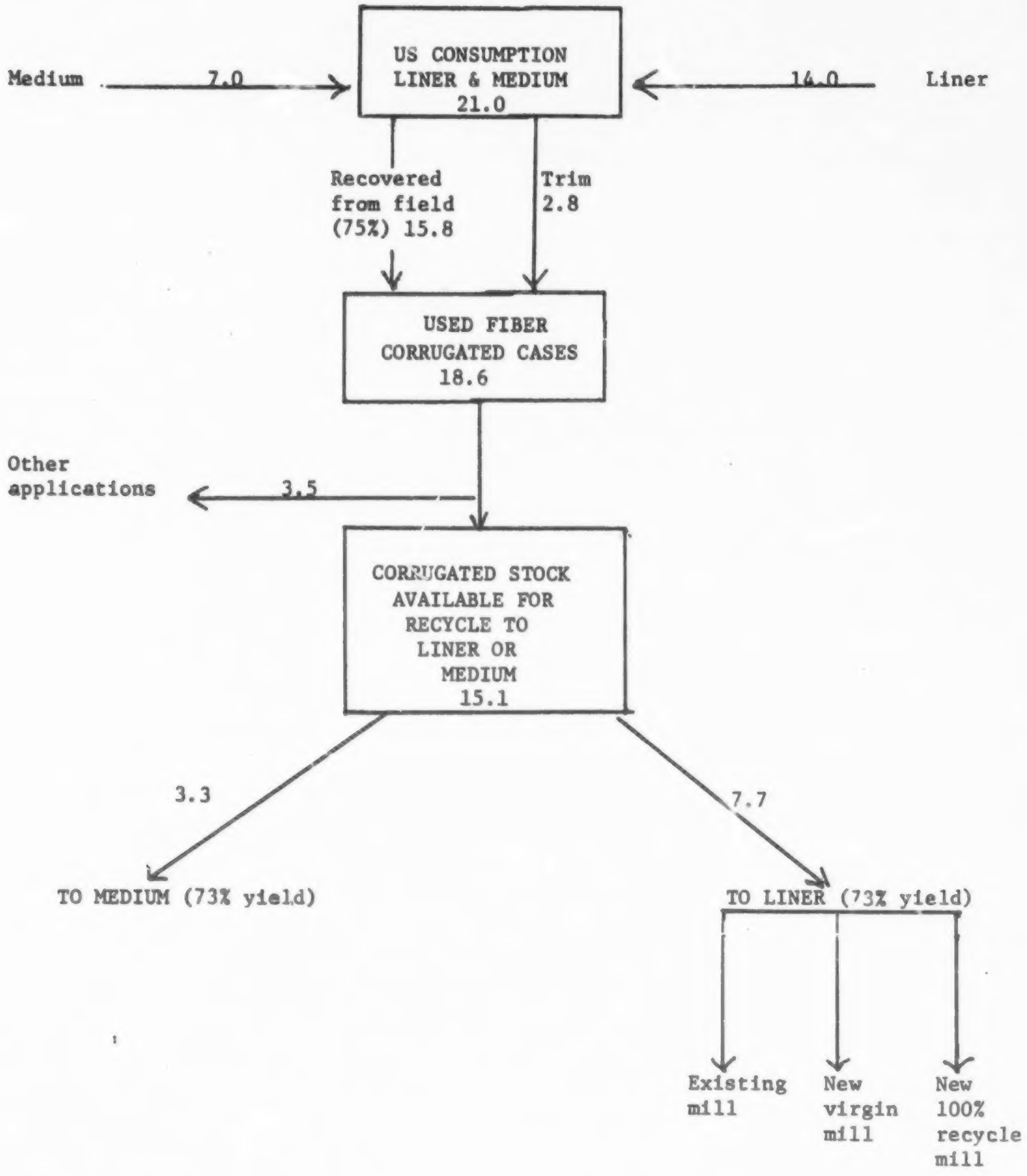
US CONSUMPTION LINER & MEDIUM 21.0
Medium
7.0
14.0
Liner
Recovered from field (75%) 15.8
Trim 2.8
USED FIBER CORRUGATED CASES 18.6
Other applications
3.5
CORRUGATED STOCK AVAILABLE FOR RECYCLE TO LINER OR MEDIUM 15.1
3.3
7.7
TO MEDIUM (73% yield)
TO LINER (73% yield)
Existing mill
New virgin mill
New 100% recycle mill

FIGURE 4. MAXIMUM SUPPLY OF SECONDARY FIBER (MM TONS) FOR LINERBOARD PRODUCTION IN 1985 UNDER STEADY-STATE CONDITIONS

Source: Arthur D. Little, Inc., estimates

for new linerboard capacity will be limited. Because 3.2 million tons of the estimated 6.4 million tons of additional capacity needed during this period already will be provided by the incremental expansion of the virgin linerboard industry, then, as a maximum, only 3.2 million tons of capacity are available for linerboard production using S.F.

Present owners of Kraft linerboard mills have little incentive to convert their facilities to utilize secondary fiber because, as indicated above, they have huge capital investments in woodlands and pulp mills. Furthermore, the existing tax structure also rewards them by treating their woodland profits as capital gains. Thus, in 1985 the maximum quantity of secondary fiber that might be used, considering this limitation of capacity, would be about 3.2 million tons, rather than the availability of 7.7 million tons of secondary fiber raw material. If we include the present S.F. capacity of 0.3 million tons, then, according to this analysis, a total of 3.5 million tons of S.F. would be recycled into linerboard in 1985. This is equivalent to a recycling level of about 20 percent. In 1978, the maximum recycling level, estimated on the same basis, would be about 10 percent. Note that these are maximum values for the linerboard industry as a whole.

According to this analysis, the availability of S.F. capacity for linerboard production will grow more rapidly in the 1978 to 1985 period than the potential supply (Figure 5). But even in 1985 the potential supply of S.F. for linerboard production is estimated to be more than twice the potential available production capacity. However, this analysis does not consider the limitations imposed by geography or economics. These will be discussed in the next section.

RESPONSE OF LINERBOARD INDUSTRY TO ALTERNATIVE RECOMMENDATIONS

In an earlier section, where alternative ways of changing specifications were reviewed (Selection of Solid Waste Reduction Opportunities), we recommended two effective approaches for modifying the purchase specification for linerboard: (1) to specify the use of a percentage of S.F. and (2) to specify a lighter weight product that would still meet the required performance characteristics.

To determine the relative economics of these alternatives, we developed a number of response models. Each of these models is based on a "model case" manufacturing plant of a given size and location that produces a product to certain specifications.

Many factors are considered in a decision to construct a new linerboard manufacturing facility. Some of these are:

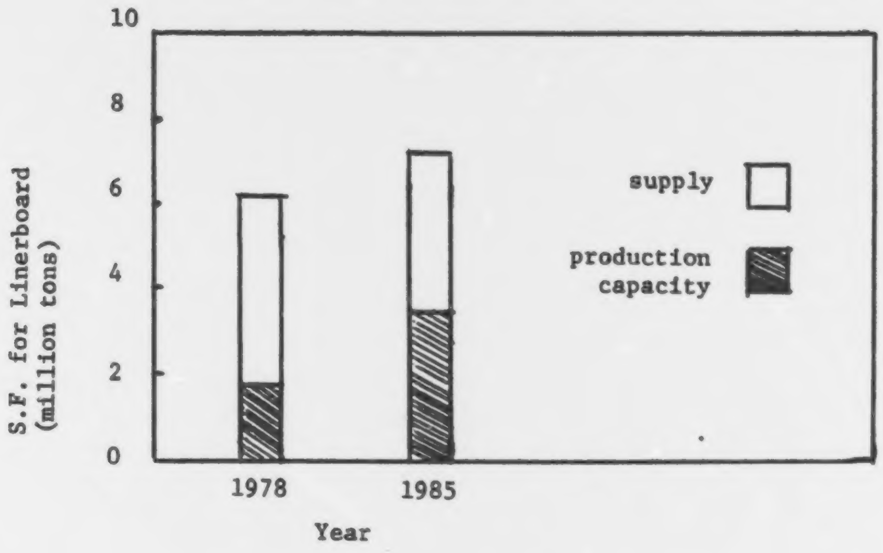

FIGURE 5. MAXIMUM SUPPLY OF S.F. FOR LINERBOARD MANUFACTURE AND MAXIMUM PRODUCTION CAPACITY FOR S.F. LINERBOARD

Source: Arthur D. Little, Inc., estimates

1. location of the raw material supply--in the case of virgin Kraft linerboard, the supply is derived from forests that are away from high population centers; and in the case of secondary fiber linerboard, the supply comes from the more densely populated areas.

2. location of the markets relative to the manufacturing site.

3. cost and availability of the raw materials.

4. transportation costs for raw materials and finished products.

5. quality of products from competing processes.

6. character of the industry associated with the existing facilities.

To understand the process economics based on secondary fiber and virgin Kraft for the manufacture of linerboard, we first considered a number of manufacturing operations that are presently in existence or could exist, if the conditions were provided. Plant investment and operating costs have been developed for each model manufacturing operation.

Assumptions

In constructing our models we made the following important assumptions:

1. It is possible to duplicate the strength properties of virgin Kraft linerboard by using 100 percent S.F. and additives such as polyacrylamides, carboxymethylcellulose, starch, etc. (Without additions, only 70 percent S.F. could be used.)

2. The cost of these chemicals and other processing treatments required to meet this objective will still allow S.F. linerboard to compete on a cost basis with the virgin product.

3. The S.F. linerboard should have the same strength as the virgin Kraft board.

4. The price of used corrugated cases that provide the furnish for the board will not increase significantly with greater demand.

We are reasonably confident that Assumption 4, which relates to the cost of S.F. furnish, will be proven valid. Based on the estimates indicated in Figure 5, the potential supply of S.F. is more than sufficient to meet the estimated maximum demand, which is determined by the limitations of capacity. The validity of this assumption is examined more closely below.

The greatest degree of uncertainty is associated with Assumptions 1, 2, and 3. However, the existence of facilities today that successfully produce linerboard from 100 percent S.F. suggests that these assumptions are not unreasonable. One word of caution, though: these assumptions must be thoroughly explored and tested before Government or industry acts on the conclusions derived from the analysis described below.

Response to a Recommendation for a Lighter-weight Product (100 percent virgin Kraft).

The manufacturing facilities in this case would have to be located near a pulpwood-producing area and remote from the consumer market. In our analysis, we considered both new and modified integrated Kraft-board mills located in Jacksonville, Florida, whose marketing area is the New York City region. These cases are defined as follows:

Case 1. An 800-ton-per-day (tpd) facility that uses 100 percent virgin fiber to produce a 42-lb/1000 sq ft linerboard (normal linerboard).

Case 2. An 800-tpd facility that originally produced a 42-lb Kraft grade but is modified to produce a 38-lb/1000 sq ft linerboard. This facility would now yield a maximum of about 725 tpd. We have assumed that the properties of this board would be equivalent to those of the 42-lb grade, if an appropriate dry-strength additive is incorporated in the product.

Case 3. For comparison, we have also considered the construction of a new facility that specifically produces this same 38-lb grade board. In this case, the production level is 800 tpd.

An 800-tpd output level is the minimum economic size for a new mill that uses primarily virgin fiber. This is not necessarily the optimal size. The optimal size is continuously increasing. Certain constraints limit this movement to larger and larger machines and larger integrated pulp-paper mills. A primary consideration is the timber resources available to the mill, More timber often means higher transportation costs, as the timber is drawn from a wider area.

The capital investment and operating costs for the alternative cases are summarized in Table 22. In comparing integrated virgin pulp linerboard facilities with linerboard operations based in part or entirely on secondary fiber, note that the capital requirements per ton of product can vary considerably from case to case. Thus, it is more pertinent to look at return on investment (ROI), rather than the margin on sales, as the primary criterion for process decisions.

The estimated investment for the "standard" Kraft mill used as the basis of comparison is $88 million for a new 800-tpd installation (Case 1). Delivered operating cost for the linerboard is estimated at $102.95 per ton, and the profit before taxes is $24.55 per ton. This provides a return on fixed capital investment (ROI) before taxes of 7.7 percent. This level of profitability is substantially below peak highs achieved in 1969 but represents the more recent performance of the industry caught in a profit squeeze (Table 23). Consequently, the calculated return is not sufficient to attract new capital investment for new installations.

Against this "standard," the operating cost and profitability of alternative schemes for reducing the solid waste problem by lowering the basis weight are compared in Table 22 (Cases 2 and 3). Case 2 represents a modification of an existing mill. But producing 38-lb board in a mill that formerly produced 42-lb board would reduce the daily capacity and, as a result, operating costs would increase about $7 per ton. These costs could not be recouped by a higher selling price and, therefore, the ROI would be reduced to 5.1 percent (Table 22). Case 2, then, also is not an attractive alternative. Industry practice has demonstrated that while the manufacturer is able to pass along some increased cost with the production of lower basis weight paper or paperboard, the increased selling price does not entirely offset the added cost. Hence the producer will avoid the manufacture of these lighter basis weight grades, as witnessed by current (1973) market conditions in the tight supply situation.

In Case 3, we consider the production of 38-lb board in a new facility designed specifically for this type of product. In this case, because the pulp and the paperboard machine that uses pulp are in balance, the operation does not incur additional cost from the under-utilization of equipment. Under these conditions,

TABLE 22

SUMMARY OF CAPITAL INVESTMENT AND OPERATING COST FOR THE MANUFACTURE OF LINERBOARD†

	Case 1		Case 2		Case 3		Case 4	
Basis: Grade	Kraft		Kraft		Kraft		Kraft with S.F.	
Basis wgt lb/1000 sq ft	42		38		38		42	
Fiber furnish	100% Virgin fiber		100% Virgin fiber with chem additive		100% Virgin fiber with chem additive		80% Virgin, 20% S.F. with chem additive	
Production tons/day	800		725		800		1000	
tons/year	275,000		250,000		275,000		345,000	
Plant operation days/year	345		345		345		345	
Investment: ($000's)								
Total plant investment	88,000		88,000		90,000		96,600	
Investment per daily ton	110.0		110.0		112.0		96.6	
	Cost ($/ton)	Cost ($000's/yr)	Cost ($/ton)	Cost ($000's/yr)	Cost ($/ton)	Cost ($000's/yr)	Cost ($/ton)	Cost $000's/yr)
Pulpwood	27.37		27.37		27.37		21.80	
Secondary Fiber	--		--		--		5.54	
Chemicals: Pulping	(0.94)		(0.94)		(0.94)		(0.75)	
Paper making	1.60		1.60		1.60		2.08	
Other chemicals dry strength	--		1.62		1.62		1.62	
Total raw materials	28.03		29.61		29.61		30.29	
Direct labor with fringes @31%	9.24		10.20		9.24		8.16	
Utilities: Fuel	2.86		2.86		2.86		3.74	
Power (purchased)	1.92		1.92		1.92		2.62	
Supplies - operating and packaging	3.75		3.75		3.75		3.65	
Factory overhead @ 80% labor	7.40		8.15		7.40		6.52	
Total conversion (Less capital related)	25.17		26.88		25.17		24.69	
Maintenance labor and supplies @3%	9.60						8.40	
Local taxes and insurance @ 2-1/4%	7.20						6.30	
Depreciation equip. & structures @ 5.7%	18.20						16.00	
Total capital related	35.00		38.50		36.00		30.70	
Total factory	88.20		94.99		90.78		85.68	
Freight out	12.00		12.00		12.00		12.00	
GS&A @ 2-1/4% selling price ($127.50/ton)	2.75		2.75		2.75		2.75	
Total delivered cost	102.95		109.74		105.53		100.43	
Sales income	127.50		127.50		127.50		127.50	
Profit before taxes	24.55	6,800	17.96	4,500	21.97	6,000	27.07	9,300
Return on investment (before taxes)		7.7%		5.1%		6.7%		9.6%

Source: Arthur D. Little, Inc.

† Mill location - Jacksonville, Florida; Market - New York City

TABLE 23

FINANCIAL PERFORMANCE OF PAPER INDUSTRY, PERCENTAGES OF NET WORTH

	1967	1968	1969	1970
		Integrated Companies		
Total assets	168	174	176	182
Sales	157	169	177	176
Profit before taxes	13.3	14.7	16.4	11.8
Federal taxes	4.8	5.8	6.7	4.5
Profit after taxes (return on investment)	8.5	8.9	9.7	7.3
Dividends	4.9	5.1	5.0	5.0
		Non-integrated Companies		
Total assets	146	144	156	159
Sales	187	184	186	182
Profit before taxes	13.1	13.5	12.1	2.8
Federal taxes	5.9	6.0	5.5	1.2
Profit after taxes (return on investment)	7.2	7.5	6.6	1.6
Dividends	3.6	3.4	4.1	3.5

Source: American Paper Institute, "Annual Capital Income Survey."

operating costs are estimated at $105.5 per ton, and the ROI at 6.7 percent (Table 22). However, as indicated earlier, new mills will probably not be built prior to 1978. When new mills are constructed, the question of a lower basis weight with an additive to compensate for any quality deficiencies should be considered carefully. In this case, the board price would need to be somewhat higher, in order to provide a satisfactory ROI, but not as high as in the case for converting an existing mill to a lower basis weight product. In either case, a higher tonnage price would be justified for the linerboard, because of the higher yield of the product (on a square footage basis).

Response to a Recommendation for the Use of S.F. in the Product

There are two basic approaches for recycling used corrugated containers in the manufacture of linerboard. In one, the secondary fiber supply is used to supplement the virgin pulp supply in an integrated pulp and paperboard manufacturing operation. (These facilities would have to be near a pulpwood-producing area, remote from the consumer market and the secondary fiber supply.) In the second, only S.F. would be used as the furnish in non-integrated linerboard mills that would be constructed near the consuming market and the secondary fiber supply.

Secondary Fiber as a Supplement (Approach 1) - These manufacturing facilities would be located near a pulpwood-producing area remote from the large consumer markets. In our analysis, we have used the same mill location that we used for Kraft-board mills, namely, Jacksonville, Florida, and the market area is the New York City region. These cases are defined as follows:

Case 4. A new 1000-tpd facility that produces linerboard from a mixture of virgin and secondary fiber. This facility would use an 800 tpd virgin pulp mill and a 200 tpd asphalt dispersion system for recovering used corrugated boxes. We have assumed that the used boxes would be shipped from the Philadelphia area. Strength additives would be used in the manufacture of the board.

Case 5. An existing 800-tpd integrated pulp and paper mill, where 160 tpd of slush pulp is replaced by an equal amount of secondary fiber. In this model, we have assumed that there is an alternative use for the displaced tonnage on another machine located on site. An asphalt dispersion system would be used to handle the S.F.

Case 4 considers the introduction of secondary fiber in a new mill that has an output of 1000 tpd. Operating costs for this case are estimated at $100.43 per ton, and the ROI at 9.6 percent (Table 22). These estimates indicate a significant cost reduction and increased profitability resulting from the inclusion of secondary fiber. But, actually, the cost reductions reflect the economies of a larger-scale operation and not the inclusion of secondary fiber. We estimate that the total operating cost and ROI would be about the same, if we were to compare this alternative to a new 1000-tpd integrated pulp and board installation that did not include secondary fiber. Furthermore, opportunities for this approach could probably occur only in the 1978 to 1985 period.

In the alternative approach, designated as Case 5, we calculated the additional investment for installing the asphalt dispersion system for handling the secondary fiber and credited the operation for the substituted virgin pulp tonnage. In this instance, the operating cost and ROI are also essentially equal to the basis of comparison, namely Case 1 (Table 24). Thus, the approach in which S.F. is used as a supplementary raw material supply is possible and can be carried out, when new virgin linerboard mills become economically attractive without increasing the cost of the linerboard product.

Secondary Fiber as the Only Fiber Furnish (Approach 2) - The economics of a juteliner (linerboard prepared from S.F. alone) manufacture are examined in this section to determine whether private industry can profitably install additional capacity in the absence of governmental incentive awards. As noted earlier, in secondary fiber processing, mill location is an important variable; it determines the availability and delivered price of the raw material and delivered cost of the finished product. We examined the process economics for two locations:

1. A large metropolitan area (Chicago), with 25 miles of customers (Cases 6 & 6A - see Tables 25 and 26).

2. A medium-sized metropolitan area (Detroit), within 50 miles of customers (Cases 6 & 6B - see Tables 25 and 27).

In both cases, we determined the factory costs for a 330-tpd jute mill, the transportation costs for the raw material and the product, and the projected profitability of a new mill. We believe that a 300-tpd facility is a minimum size plant.

Plant Costs. The estimated investment for a new 330-tpd plant located in Chicago is $18.5 million. The manufacturing cost for

TABLE 24

ESTIMATED OPERATING COSTS FOR THE PARTIAL SUBSTITUTION OF VIRGIN KRAFT PULP WITH SECONDARY FIBER (CASE 5)

Basis:
1. Assume existing 800-tpd mill--Case 1.
2. Assume existing mill can identify an alternative use for 20% of pulp production--160 tpd (55,000 tpy)
3. Increment capital investment for 160 tpd asphalt dispersion system from recovering old corrugated boxes estimated at $3,000,000.
4. Credit for virgin kraft linerboard grade of slush pulp at $54 per ton.

Item	Cost $/ton product	Cost $000's/year
Secondary fiber raw material		
Fiber - 61,000 tpy req'd. @ $22/ton f.o.b. dealer, 90% yield	24.4	1,340
Freight on S.F. raw material @ $12/ton	13.1	720
Operating cost for S.F. system		
Variable costs[†]	8.9	490
Fixed costs @ 15% investment	8.2	450
Total operating cost S.F.	$54.6	$3,000
Credit for virgin kraft pulp 55,000 tons @ $54/ton	(54.0)	(2,960)
Net operating cost for partial substitution with S.F.	$0.6	$40

Source: A.D. Little, Inc., estimates.

[†] Includes conversion cost less capital related items.

TABLE 25

ESTIMATED PROCESS ECONOMICS FOR THE MANUFACTURE OF JUTE LINERBOARD
(Case 6)

Basis:	Grade	Jute linerboard
	Basis weight lb/1000 sq ft	42
	Fiber furnish	100% secondary fiber
	Production tpd	330
	tpy	100,000
	Plant operation dpy	300
	Mill location	Chicago, Illinois
Investment		
	Total plant	$18,500,000
	Per daily ton	$56.0

Item	Cost $/ton product	 $000's/year
Raw materials		
Secondary fiber (less freight) @ $28/ton	30.61	3,061
Chemicals, including dry strength additives	13.56	1,356
Total raw materials	44.17	4,417
Conversion (less capital related)		
Direct labor w/fringe @31%	6.51	615
Utilities - fuel & power	12.00	1,200
Supplies - operating & packaging	2.75	275
Factory overhead - 100% direct labor	6.15	615
Total conversion cost (less capital related)	27.05	2,705
Capital related		
Maintenance labor & supplies @ 3% investment	5.52	552
Local taxes and insurance @ 2-1/4% investment	4.15	415
Depreciation equipment and structures @ 5.7%	10.50	1,050
Total capital related	20.17	2,017
Total factory	91.39	9,139
G.S. & A. @ 2-1/4% selling price	2.75	275
Total operating cost (less transportation in and out)	$94.14	$9,414

Source: Arthur D. Little, Inc.

TABLE 26

TRANSPORTATION COSTS, CHICAGO LOCATION
(Case 6A)

Raw material (RM) delivery system:	Local collection (delivered to plant) - 2/3 Back haul, own trucks 1/3
Customer:	3, average distance 25 miles

All products delivered by truck
All RM (100,000 tons) arrives by truck

Capacity per load:	12 tons
Number of trips:	25 per day
Equipment:	5 trucks
Manning:	4 drivers per shift, 2 shifts per day
Investment:	$125,000 for trucks and supporting facilities

Annual Operating Costs

Drivers, including fringes @ $14,000	$92,000
Operating costs: gas, oil, normal maintenance @ 20¢ per mile (206,000 mi/yr)	41,000
Truck dispatcher	12,000
Maintenance man and helper	23,000
Depreciation, taxes, and insurance @ 33%	42,000
Own truck costs	$210,000
Remaining RM delivery costs: 73,000 tons @ $5.00 per ton†	365,000
Total freight costs for 100,000 tons of product	$575,000

Source: A. D. Little, Inc., estimates.

† Assume 64-mile average one-way haul ($5.75 per ton) of product.

TABLE 27

TRANSPORTATION COSTS, DETROIT LOCATION
(Case 6B)

Delivery system:

Back haul (own trucks)	1/3
Local trucks	1/3 @ $5.00 per ton
Rail from 200 miles	1/3 @ $7.60 per ton

Customers: 3, average distance, 50 miles

Note: All investment and operating costs for own trucks are directly proportional to average distance to customers. Therefore, investment and operating costs for own trucks in Case 6B are twice those in Case 6A.

Investment: $250,000 for trucks and supporting facilities

Annual operating costs:

Own trucks	$420,000
Local trucks: 37,000 tons x $5.00 per ton	185,000
Rail: 36,000 tons x $7.60 per ton	273,000
Total freight costs for 100,000 tons of product	$878,000 ($8.78 per ton of product)

Source: Arthur D. Little, Inc., estimates

juteliner, exclusive of freight in or out, is $94.14 (Table 25). This cost includes an estimate of $13.16 per ton for a dry-strength additive that can bring the strength of the juteliner to the same level as that for virgin liner. As noted earlier, this estimate is based on an important assumption that should be examined in detail.

According to our analysis, the investment per daily ton of juteliner is $56,000, while the investment per daily ton of virgin liner ranges from $97,000 to $114,000. As noted below, this considerably lower capital cost for a juteliner mill permits attaining a return on investment that is higher than that for a virgin liner mill, even though the juteliner has a higher factory cost. This is another reason why our economic comparisons are based on the return on investment.

Supply of Raw Material. A 330-tpd juteliner mill requires about 110,000 tons per year of used corrugated boxes. As noted earlier, from 1.1 to 1.2 tons of corrugated paper stock are required to make one ton of S.F. linerboard. Today, the U.S. per capita consumption of corrugated boxes is about 120 lb per year (according to the API), and the present nationwide average recovery level for used corrugated boxes is about 25 percent. Most of this paper stock is used in the manufacture of folding boxboard and construction products. If new juteliner capacity is installed, an additional supply of used corrugated boxes will be needed. This will require either tapping a larger geographical area, or increasing the yield in the present supply areas, or both. In our analyses, we have assumed that the present concentrated waste-producing areas will be utilized more intensively, and that the remainder of the requirements will be met by tapping the remote areas that are presently underutilized. We assumed that the average recovery rate in the United States will be raised to 35 percent.

At present, the Chicago area has a population of about 9 million people. Assuming a recovery rate of 25 percent, which we believe is reasonable based on related studies, a total of 135,000 tons per year of used corrugated containers would be recovered (Figure 6). The additional 110,000 tons per year of raw material for one new 330-tpd juteliner mill (110,000 tpy) can be obtained by increasing the recovery rate to 35 percent and expanding the "drain area" to 11 million people. In the event the process of separating the liner fraction from corrugating medium fraction in the recovery of old corrugated boxes becomes a commercial reality, the volume of raw material required to sustain a 100,000-tpy juteliner board will be increased to about 160,000 tpy.

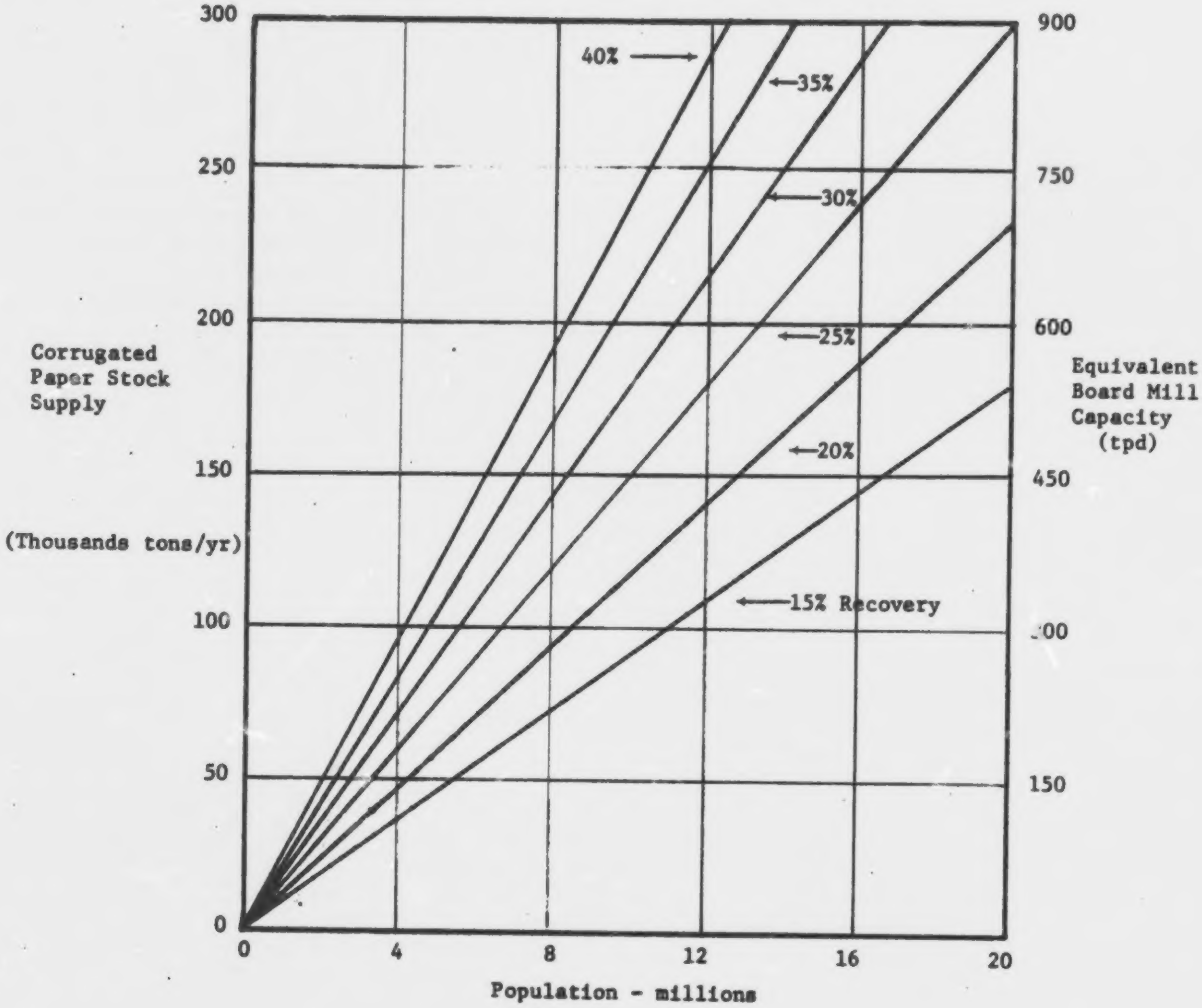

FIGURE 6. POTENTIAL SUPPLY OF USED CORRUGATED CONTAINERS AT DIFFERENT RECOVERY RATES

Basis: Containerboard consumption 120 lb/person/yr

Source: Arthur D. Little, Inc.

In Detroit, according to an Arthur D. Little, Inc., survey, approximately 70,000 tons of used boxes are currently being recovered per year from a population of about 4.5 million (recovery rate: 26 percent). We assumed that about 70,000 tons per year of additional corrugated paperstock could be obtained by raising the recovery rate to 35 percent and enlarging the drain area to a 50-mile radius from the plant. Another 30,000 tons could be obtained by rail transport with an average haul of 200 miles. The use of rail transport would permit tapping many smaller regional areas near Detroit, such as Flint and Pontiac, where the potential supply of used corrugated boxes now may be underutilized.

Our analysis also assumed that the selling price for used corrugated boxes would not change, if the present 25-percent recovery rate is increased to 35 percent. On the basis of a number of interviews with experience participants in the waste paper market, we believe that the higher recovery rate can be obtained at no increase in unit price, if a steady market develops for the additional material. Although a temporary price increase will occur when the additional demand for corrugated stock is felt, after new collection channels have been established, the price should settle essentially to its previous level. The key element in maintaining the present price level is to establish the increased demand as permanent, rather than temporary. We do not believe that the recovery rate can be increased indefinitely without promoting an increase in the unit price of corrugated stock, but we believe that the assumed 35 percent rate is well within the capabilities of the present collection systems and that no cost increase will be necessary.

Transportation Costs. In our detailed analysis of the transportation costs for a Chicago plant (Table 26, Case 6A), we assumed that there are three customers for the mill output, located an average of 25 miles from the mill. All of the product is delivered by company-owned trucks, and one-third of the raw material is picked up by the company trucks on back-haul. The remaining two-thirds of the product is delivered by truck by local dealers at an average trucking cost of $5.00 per ton. Five trucks, with four drivers per shift (two-shift operations), are required. The investment for trucks and supporting facilities is $125,000, and the total annual operating cost for delivering all the product and one-third of the raw material is $210,000 ($2.10 per ton of product). The total transportation costs, then, are $5.75 per ton of product.

In the analysis of the transportation costs for a Detroit location (Table 27) the product is delivered by truck from an average distance of 50 miles, and one-third of the required raw material is delivered on the back-haul. An additional one-third of the raw material is assumed to arrive by local trucks ($5.00 per ton), and the final one-third, by rail from an average distance of 200 miles at $7.60 per ton (Table 28). Therefore, the total transportation costs are $8178 per ton of product (Table 27).

The alternative to operating a company fleet of trucks becomes prohibitively expensive, if the mill has to pay ISCC (Interstate Commerce Commission) rates for hauling. Figure 7 illustrates ISCC rates for various minimum loads and distances.

Profitability Analysis. The profitability of the ventures illustrated by Cases 6A and 6B exceeds the profitability for a virgin fiber mill making linerboard; operations in the larger metropolitan centers are more profitable than those in smaller centers (Table 29). Moreover, the total investment for an economic jute linerboard plant is only one-fifth that of a virgin liner plant. The ROI for the Chicago area is 14.8 percent; the ROI for the Detroit area is 13.1, as compared to the 7.7 percent ROI for a standard 800-tpd Kraft linerboard mill. We conclude, then, that for geographical areas which can be represented by Cases 6A or 6B, jute liner mills are economically attractive, without direct governmental financial assistance.

This analysis indicates that under the present freight structure, and under our assumptions, jute linerboard can attain a superior ROI, if: (1) the plant is located in a large metropolitan area with collection and deliveries by truck within a maximum 75-mile radius of the plant; and (2) the plant is located in an area with several medium-sized metropolitan centers served by trucks within the 75-mile radius.

Opportunities for Jute Liner Manufacture. As shown in Case 6B, an area with about five million people in a radius of 50 miles will support an economic jute liner mill. If an area has 10 million people, it will support two economic mills, or a single, quite profitable mill.

We estimate that today approximately 14 potential sites are available in the U.S. for jute liner mills, in addition to the one existing mill (Table 30). According to this analysis, the total capacity for the 14 additional mills would then be about 1.4 million tons per year.

Conclusions - Based on this response model analysis, which is dependent upon the assumptions listed earlier, about 1.4 million tons of additional S.F. might have been used economically in 1972 for linerboard production, if the Government purchasing practices

TABLE 28

RAIL RATES - TRANSPORTATION COST FOR PAPERSTOCK
($/ton)

Miles	Southern (80 M lb)	Eastern (80 M lb)	Western (50 M lb)
100	3.60	5.60	5.80
150	4.30	6.90	7.30
200	5.10	7.60	8.40
250	(5.70)†	8.20	9.20
300	(6.60)	8.70	9.90
350	(7.30)	9.10	10.60
400	(8.20)	(9.80)	11.20
450	(9.00)	(10.30)	11.60
500	(10.00)	(11.50)	12.50

Source: Tariff Authorities

† Indicates A. D. Little, Inc. extrapolations from published sources.

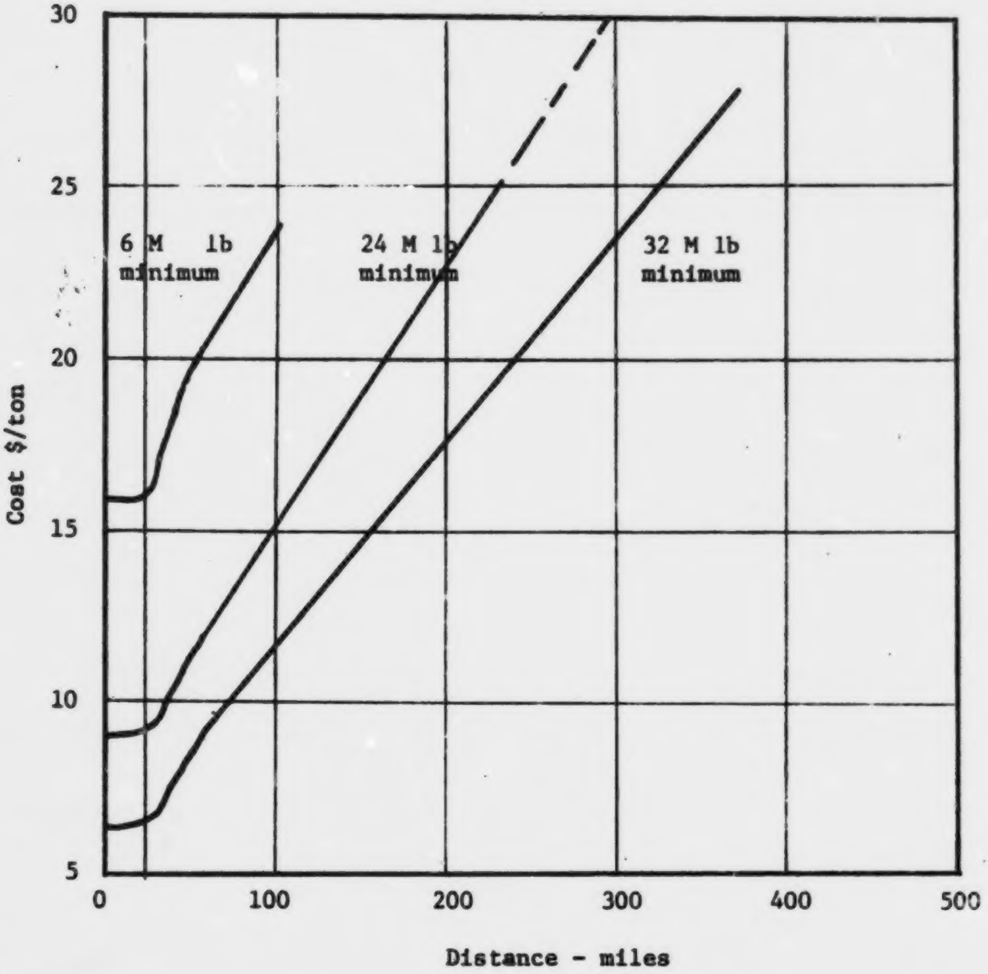

FIGURE 7. TRANSPORTATION COST FOR PAPER STOCK IN THE NEW ENGLAND REGION (TRUCK RATES)

Basis: Class V commodity products

Source: New England Motor Rates Bureau

TABLE 29

PROFITABILITY ANALYSIS - JUTE LINERBOARD MANUFACTURE

Profit on a per ton basis	Case 6A (Chicago)	Case 6B (Detroit)
Factory costs[†]	$ 91.39	$ 91.39
Freight costs	5.75[‡]	8.78[§]
GS & A	2.75	2.75
Total costs, delivered	$ 99.89	$102.92
Selling price	127.50	127.50
Profit before taxes	$ 27.61	$ 24.58
ROI (before taxes)		
Investment for plant	$18,500,000	$18,500,000
Investment for trucks	125,000[†]	250,000[§]
Total investment	$18,625,000	$18,750,000
Annual profit before taxes	2,761,000	2,458,000
Return on investment (before taxes)	14.8%	13.1%

Source: A. D. Little, Inc., estimates

[†] From Table 25

[‡] From Table 26

[§] From Table 27

TABLE 30

OPPORTUNITIES FOR CASE 6B OPERATIONS

Location	Multiples of 5 million population in 50-mile radius
New York City	3†
Chicago	2
Los Angeles - San Diego	3
Detroit	1
Philadelphia	1
Baltimore - Washington	1
Ohio	1
San Francisco - Oakland - San Jose	2
	14

Total additional capacity: 14 x 100,000 tons = 1,400,000 tons/yr.

Source: A. D. Little, Inc., estimate.

† Not including one existing mill.

had been changed, the industry had complied, and the ripple effect had been 100 percent. This analysis realistically considers the geographical constraints to recycling corrugated secondary fiber. Consequently, if the existing S.F. linerboard capacity of 0.35 million tons per year is included, a total of 1.75 million tons (or 15.1 percent of today's annual linerboard production) would be used. This value corresponds to 18.2 percent of U.S. consumption of linerboard. Recall that our earlier analysis, which did not consider demographic factors or return on investment indicated a maximum recycle rate of 20 percent--a value not much greater than the one derived by our model analysis.

The above analysis also indicates that of the two alternative ways of decreasing the quantity of solid waste, the recommendation to incorporate a certain percentage of S.F. in the product is preferred to the recommendation that requires the specification of a lighter-weight product with the necessary performance characteristics. Moreover, based on the above profitability analysis, industry would incorporate S.F. in linerboard primarily by constructing new small mills (300 tpd or larger) that use 100 percent S.F. as the furnish, rather than add on secondary fiber processing equipment to existing virgin Kraft mills.

RECOMMENDED SPECIFICATION CHANGE FOR LINERBOARD

We recommend that a new specification be introduced that requires linerboard producers to certify that they use an average of "X" percent S.F. in their total linerboard production, if they wish to bid on a Government purchase, rather than to certify an average of "X" percent in the product. A preferred procedure would be for the Government to first announce that the new specification was to be introduced, so that the linerboard producers would be sure to have adequate records. (Actually, today the manufacturers report their production statistics to their industrial association and the Government.) One year or six months following the announcement, the Government would then ask for bids. The linerboard producers could then certify that over the past year (or 6-month period) they used on the average at least "X" percent S.F. in manufacturing their linerboard. This certification procedure is similar to that required under the Fair Employment Practices Act and, therefore, will probably require auxiliary legislation.

If the assumptions used as a basis for the economic calculations in this report can be proved to be valid, the Government should move to change specifications. It should require that the amount of secondary fiber in the linerboard furnish be changed gradually, consistent with the growth in demand for linerboard and the opportunities for installing secondary fiber linerboard facilities. Thus, on the basis of our model analyses, we recommend specifying the S.F. level at 5 percent in 1973 and increasing it about 3 percent every three years to a total of about 15 percent by 1985. The concentration could be adjusted either upward or downward each bidding period, depending upon the response of the industry.

Obviously, specifications pertaining to linerboard automatically affect those for corrugated cases; therefore, new specifications will eventually have to consider not only linerboard, but the corrugating medium. The rationale for modifying the specifications for the corrugating medium can be developed in the same fashion as described above for linerboard. Recall that for the sake of simplicity we focused on linerboard in the economic models and in the subsequent recommendation to modify the present Government specification. This analysis is only an example of the methodology that one would use in considering changing specifications for paper and paperboard products.

Rationale for Recommendation

We believe that requiring a certain average percentage of secondary fiber in the total production used by the linerboard supplier will be more effective in promoting the use of secondary fiber throughout the industry than requiring only that the linerboard (or corrugated case) purchased by the Government has a certain S.F. content, as the present GSA specification reads. For example, during a 6-month period in 1972, the GSA instituted a test program to determine industry response to a specification change that would require all suppliers to the Government who use corrugated shipping cases in level "B" packaging to use cases with 35 percent "reclaimed fiber."

Industry, however, was unable to respond to these bids, because the suppliers of these packaging cases generally refused to supply the Government bidders with only a small number of corrugated cases that met the Government specifications. This was true whether or not the supplier of corrugated cases could obtain the raw materials from their suppliers.

We believe that the recommended specification change should tend to maximize the "ripple" effect. Today, the specifications require a percentage of secondary fiber in the purchased board, but the only potential suppliers of this type linerboard are the present manufacturers of secondary-fiber linerboard; there is no incentive for the virgin Kraft linerboard producers to add on secondary fiber-treating facilities to their existing mills. Consequently, the "ripple" effect is minimal, and there is no net reduction in the generation of solid waste.

As indicated earlier, Government purchases at most affect only about 5 percent of the domestic consumption of linerboard, if one considers both the direct purchase of board as well as that purchased indirectly with packaged materials. Therefore, the Government requirements for linerboard can be met largely by the present producers of secondary board. While the suppliers of various packaged products to the Government (for example, cans of tomato soup) would prefer to have only one grade of linerboard for their packaging with the present specification changes, they would have little leverage to force suppliers to meet all of his linerboard requirements with the Government's specified secondary-fiber content. In fact, the major linerboard producers would be extremely reluctant to do so, as noted above, because adding secondary-fiber treating facilities to an existing virgin Kraft mill would not be attractive. We believe that if the specifications were applied in this fashion, buyers of packaging materials (e.g., Campbell Soup, Procter & Gamble, Scott Paper Co., etc.) would probably either double-stock and reserve secondary fiber linerboard for Government orders, or simply decide not to go after the Government orders, because of the complex inventory problem for both their packaging materials and packaged goods. And, as the GSA experiment established, these Government suppliers of packaged goods would rather not bid. Consequently, even under optimum conditions the Government would only purchase Government secondary-fiber linerboard from existing manufacturers. The present industry structure, where most of the production is supplied by virgin Kraft producers would remain unchanged.

On the other hand, if Government purchasing practices are altered so that all linerboard materials purchased by the Government (either as board itself or in a corrugated container with other purchased materials) would be supplied by linerboard producers who use an average of "X" percent of secondary fiber in all of their linerboard operations, the situation would be quite different. In this case, many of the existing virgin Kraft linerboard suppliers would be able to qualify as suppliers to the Government by installing sufficient secondary fiber producing facilities in appropriate locations. Then, the packager (i.e., Procter & Gamble, Campbell Soup, Scott Paper Co.) would be able to select his purchase of corrugated from a number of suppliers. Moreover, the packager would not be concerned about the make-up of the specific packaging material he purchased; he would be free to take delivery from the linerboard or box plant that could provide him with the material most economically. At present, linerboard suppliers typically "swap" tonnage, and this practice could continue.

Because (under our assumptions) the quality and the cost of linerboard made from secondary fiber or virgin Kraft would be the same, the packager would have no need to segregate the two types of board and double-stock. Consequently, he would effect substantial economies both in the inventory of packaging materials and packaged goods, and he would have a real economic incentive to persuade his linerboard supplier to qualify under the new Government specifications. Furthermore, the linerboard supplier would probably comply with the packager's wishes, because the supplier would not have to ship only a few cases with the required S.F. to his packager customer. Therefore, we believe that the net result of our recommendations would be a strong economic incentive for the suppliers of linerboard to install secondary fiber facilities to qualify under the new Government specifications.

An Alternative Specification Strategy

Let us examine the alternative stragegy, where the Government purchasing specification requires the packager to use an average of "X" percent secondary fiber linerboard for packaging products for the Government. We believe that this practice would not be effective in reducing solid waste, because the packager would purchase his required percentage of secondary fiber linerboard from the present manufacturers of such products. If, as we have assumed, the quality and cost of the secondary fiber and virgin Kraft linerboard were the same, the packaging firm would be relieved of the need to double-stock packaging supplies and packaged finished goods. However, there would be no incentive for the suppliers of virgin Kraft linerboard to alter their present manufacturing operations, and the packager would have no reason to request such changes, because their secondary fiber requirements could be met by purchasing from the few present manufacturers of secondary-fiber linerboard.

IMPACT OF THE RECOMMENDED SPECIFICATION CHANGE ON THE ECONOMY AND ON SOLID WASTE GENERATION

If the Government specifies that the linerboard suppliers use an increasing percentage of S.F. in their manufacturing plants to qualify as a Government bidder, and if the "ripple" effect is substantial, as we expect, then this action will have a primary effect on the supply and suppliers of paper stock used to produce S.F., and the suppliers of S.F. linerboard. The effect of this recommendation on the structure of the linerboard industry and the associated transport industries will be significant, but the effect on employment and the balance of trade will be minimal.

Impact on the Use of Raw Materials

If the recommended specification change is observed by the entire industry then, by 1985, 2.7 million tons of S.F. (or 3.2 million tons of paper stock) will be utilized annually in the manufacture of linerboard, as compared to the baseline forecast of 1.47 million tons of S.F. (or 1.6 million tons of paper stock). We estimate that the annual consumption of S.F. will gradually increase from 0.35 million tons to 1.27 million tons between 1972 and 1978. After 1978, we expect that the consumption rate will increase slightly, because we believe new mills will go on stream during that period (Table 31).

Every ton of secondary fiber used replaces about two tons of wood. Thus, by 1985, the drain on our forest resources would be reduced by as much as 5.4 million tons per year or by approximately 1.35 million trees (ca. 4 tons of wood per tree). This is equivalent to about twice the tonnage or number of trees indicated by our baseline forecast (Table 21).

The shifts in the use of other raw materials will be minor, even though the unbleached Kraft pulp industry uses substantial quantities of chemicals, primarily salt cake and limestone. At present, the Kraft mills use about 110 lbs. of salt cake per ton of output, which represents an annual consumption of 640,000 tons valued at about $19 million. However, this annual tonnage is expected to decline to approximately one-half the present volume by 1985, because of the increasing demands for pollution abatement and the trend of the industry to generate salt cake internally. As a result, the impact of our recommendations on salt cake consumption will be minimal. On the other hand, if the production of S.F. linerboard increases, the demand for chemical additives to impart adequate board strength will increase substantially.

Impact on the Linerboard Industry

The structure of the linerboard industry will be altered considerably in the shift from virgin Kraft to secondary-fiber raw materials, if the recommendation is followed by most of the industry. Under these conditions, we expect that consumers of secondary fiber will find it expedient to form a closer association with paper-stock dealers. No doubt this will lead to the integration of paper-stock dealers with linerboard producers.

TABLE 31

FORECAST OF AVERAGE SECONDARY FIBER CONTENT OF LINERBOARD IF RECOMMENDATION IS ADOPTED BY THE ENTIRE INDUSTRY
(1971 to 1985)

Year	Linerboard production	Average furnish composition		
		Virgin †	S.F. †	% of S.F.
1971	11.6	11.2	0.35	3.0
1973	13.0	12.5	0.54	4.2
1975	14.0	13.2	0.81	5.8
1978	15.2	13.9	1.27	8.3
1980	16.0	14.4	1.64	10.2
1982	16.8	14.8	2.04	12.1
1985	18.0	15.3	2.70	15.0

Source: Arthur D. Little, Inc., estimates

† Million tons.

We have commented earlier that the industry is dominated by a few very large producers, and that the linerboard producers are integrated forward to box production, so more than 85 percent of the box plants are captive operations. Also, as indicated in a previous section, virgin Kraft linerboard producers have a major incentive to utilize pulpwood and make Kraft pulp. Therefore, they are less interested in using secondary fiber. Consequently, the initial interest in using secondary fiber to produce linerboard may come from: (1) the few remaining independent box plants, (2) consumers of specialty linerboard products, and (3) a few of the larger paper-stock dealers.

If Government specifications require that on the average the linerboard furnish should contain a certain concentration of secondary fiber, the large producers will have a substantial incentive to acquire existing secondary fiber operations or build their own. In the long term, this would further the consolidation of the industry and, as an end result, there would be a few large suppliers of both virgin and secondary-fiber linerboard products.

Based on the analysis of the response models, increased use of secondary fibers in the linerboard industry between 1972 and 1978 will arise largely from 100-percent-jute linerboard mills rather than from any substantial add-on of secondary-fiber capabilities to existing Kraft mills. However, between 1978 and 1985, add-on of secondary-fiber facilities to existing Kraft mills could be more plentiful. Nevertheless, we estimate that by 1985, if the recommendations are followed by most of the industry, less than 10 percent of the S.F. consumed by the linerboard industry will be used in new Kraft 1000-tpd mills with auxiliary S. F. facilities.

The opportunities for constructing new virgin Kraft mills, with or without secondary fiber facilities, will be few in the 1972 to 1978 period, as noted earlier. Some of the reasons for this are: (1) the long lead time (30 months) for new construction; (2) the ROI for a large linerboard mill is not attractive under the present price structure. But, in the 1978 to 1985 period, some new Kraft linerboard mills may be build.

Impact on Employment

Based on our earlier analysis, if compliance with the specification requiring an average of 15 percent S.F. in the linerboard furnish is 100 percent (the maximum effectiveness that can be achieved by the "ripple" effect), about 2.7 million tons of S.F. per year would be consumed by the industry in 1985 (Table 31). The baseline forecast for that year predicts an annual consumption of 1.37 million tons (Table 21). The difference between these values is 1.33 million tons. Based on our analysis of the response models, this volume could be used by about 14 secondary fiber mills, each with a capacity of 330 tpd or 100,000 tpy.

A 100,000 tpy S.F. mill typically uses about 100 workers or about one worker per thousand tons of annual output, including mill labor, truck drivers, and labor for waste collection. Thus, in 1985, when the 14 plants would be needed, a total of about 1400 workers would be employed.

The virgin Kraft industry, on the other hand, uses more workers per annual ton of output. For example, a typical 800-tpd or 240,000 tpy Kraft mill uses 1000 workers or about 4.2 workers per thousand tons of output. This includes mill labor as well as labor required to bring the wood to the mill. The 1.33 million tons per year of additional S.F. needed by 1985 will require about six 800-tpd mills and 6000 workers. Consequently, if compliance with our recommendation is complete, then by 1985 the addition of about 4500 workers to the labor force will not be needed. As cited earlier, the increase in the demand for S.F. will be gradual. In 1980, therefore, about 2400 fewer jobs will be available, and in 1975 about 800 jobs. These estimates are very approximate. They indicate only that employment by this industry will grow somewhat more slowly than otherwise; it is not a question of putting someone out of work. In summary, then, employment effects are small.

However, increasing the use of S.F. in linerboard will affect the geographic pattern of employment, for S.F. facilities would be located in urban areas, rather than the rural areas where virgin Kraft mills are presently located. Thus, an employment shift would occur, and more jobs would become available in the metropolitan areas.

Virgin Kraft and S.F. linerboard mills employ highly skilled, skilled, and unskilled labor. Usually both types of mills use approximately the same distribution of skills; about 10 percent highly skilled; 40 percent skilled; and 50 percent unskilled. The move toward S.F. facilities, then, will not affect the skill factor.

Impact on Transportation

A shift from virgin Kraft to S.F. linerboard will call for a shift from the use of rail transportation to trucks. Pulp mills use both truck and rail transport to haul the wood to supply their requirements and deliver the finished products to the market.

However, as indicated in our analysis, the manufacturers of S.F. linerboard would rely heavily on truck transport to collect and transport the paper stock to the mill and deliver the linerboard to the market areas. A major distinction in transportation requirements of the Kraft and S.F. board industries is that the virgin Kraft industry must normally ship its product longer distances to the market area. An example of how truck rates vary with distance is shown in Figure 7.

Furthermore, supplying the pulp mills requires shipping about 4.5 tons of wet wood a distance of 75 to 250 miles for each ton of linerboard production. Thus, virgin Kraft linerboard production involves shipping four times as much weight as S.F. linerboard production. But, this is not the entire story, because wet wood can be packed at a density of 60 lb per cubic foot, while the typical paper stock used in linerboard production is packed at a density of about 18 lb per cubic foot. On this basis, one ton of virgin Kraft linerboard requires 33.4/cu ft of wood, and one ton of S.F. linerboard requires 111 lb/cu ft of paper stock. Another factor in this analysis is that the rates charged for rail transport of paper stock are higher than those charged for the wet wood. This difference in transportation rates for virgin and secondary material is being studied under another EPA contract.

Impact on Foreign Trade

Because of the excess supply of wood in North America,* the balance of trade will continue to be favorable to the United States, whether or not the recommended specification is followed by industry. Demand from overseas determines the volume of exported board. Today, exported board uses virgin Kraft rather than S.F., and we believe that this practice will continue. Consequently, if the U.S. linerboard industry moves to more intensive recycling and uses more S.F. board, the demand for export board will have to be met from a smaller supply of virgin Kraft linerboard. At present, as indicated previously, S.F. linerboard accounts for 3 percent of U.S. production; in 1985, it could account for 15 percent. Because these changes will be gradual, we believe the impact of our recommendations on foreign trade will be minimal.

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*The U.S. Department of Agriculture Forest Service has presented statistics showing that the growth of both hardwood and softwood in the United States is in excess of the annual cut. This differential is expected to narrow but growth will still exceed cut by 1990.

Impact on the Generation of Solid Wastes

We have estimated that without any Government action the composition of the average fiber furnish in linerboard manufacture will rise from the present 3 percent to about 5 percent in 1978 and about 7.6 percent in 1985. Based on a yield of one ton of S.F. from 1.2 tons of used corrugated, the baseline forecast indicates that the consumption of used corrugated cases will increase from the present annual volume of about 0.42 million tons to about 1.64 million tons in 1985 (0.89 million tons in 1978). If our recommendation is adopted by the entire industry, the annual consumption of corrugated stock will increase to 1.52 million tons in 1978 and 3.24 million tons in 1985 (Figure 8). Consequently, this increase in consumption would remove an additional 0.63 million tons of corrugated waste per year by 1978 (1.52-0.89) and 1.6 million tons per year by 1985 (3.24-1.64).

On this basis, about 12 percent of the total tonnage of available corrugated cases (estimated at 20.3 million tons per year in 1985) would be recycled by 1985, if this recommendation is followed by the industry. Similar recommendations should be developed for the other paper and paperboard products, especially those used in packaging. If the degree of compliance with these new recommendations is high, this strategy can be effective in reducing urban solid wastes.

THE USE OF SUPPLEMENTARY ECONOMIC INCENTIVES

In a previous section, we indicated that the maximum recycling rate for the linerboard industry would be about 20 percent by 1985, based on the potential availability of S.F. capacity by that time. If one then adds the additional constraint of geography, namely, that only large metropolitan areas can supply corrugated paper stock, the maximum recycling rate is about 15 percent.

Because the difference between the estimates for these two rates is small, the use of auxiliary economic incentives to increase the recycling rate from 15 percent to 20 percent would have limited effectiveness. However, if the linerboard industry does not respond adequately to the recommended specification change, the use of auxiliary incentives, such as an incentive payment to promote recycling, may be appropriate.

As a maximum the secondary-fiber content of linerboard might increase to 35 percent, if all of the increase in demand in the 1972 to 1985 period were satisfied by secondary fiber. However, to accomplish this, the normal expansion of virgin Kraft mills

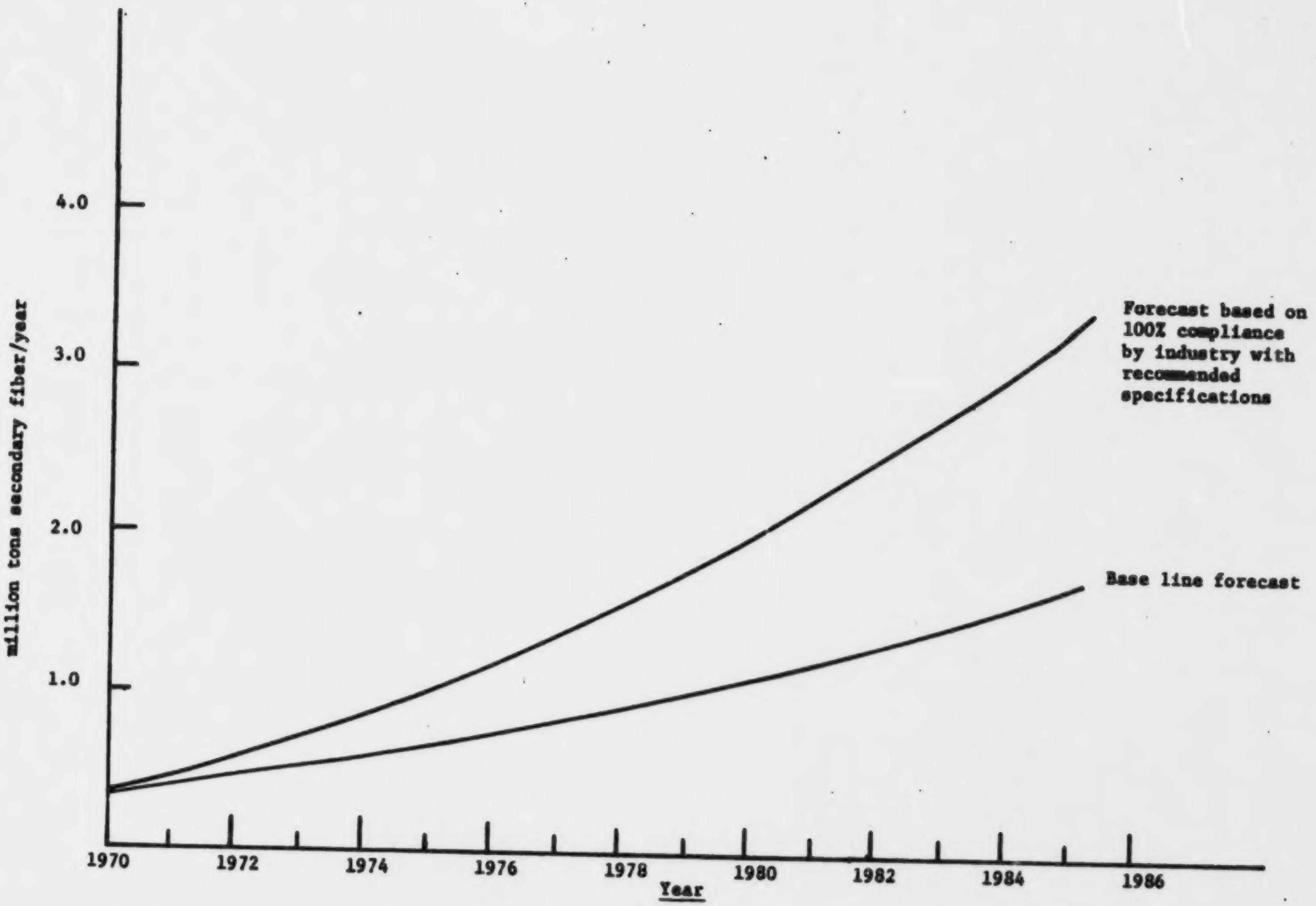

FIGURE 8. POTENTIAL CONSUMPTION OF SECONDARY FIBER IN U.S. LINERBOARD PRODUCTION

Source: Arthur D. Little, Inc., estimates

via maintenance, rebuilds, and construction would have to be curbed. This would result in a major change in the operating and financial structure of the linerboard industry.

III. METALS

OVERVIEW

Iron and Steel

The iron and steel industry is composed of three main segments:

1. Integrated steel companies that produce: (1) pig iron from virgin raw materials (ore) and some scrap; and (2) steel and steel-mill products from pig iron. These companies use blast furnaces to make pig iron, and open hearth, basic oxygen, and electric furnaces to manufacture steel.

2. Steel companies that do not have facilities for converting virgin raw materials to pig iron, but rather purchase pig iron and ferrous scrap and produce steel-mill products.

3. Iron and steel foundries that melt pig iron and scrap to produce ferrous castings.

Industry statistics generally differentiate between the first two producers of steel-mill products and the latter foundries.

Technology - Most raw iron and steel is produced by converting iron ore to pig iron using coke and limestone in blast furnaces, which are large-scale installations that usually feed a number of satellite steel furnaces. Blast furnaces consume only a small amount of scrap as a portion of iron output; about 5.3 million tons (5.8 percent) of scrap was used in 1970 to produce 91.4 million tons of pig iron.[8] Most of the pig iron is used by the steel industry, but about 3.6 million tons was shipped to users outside this industry in 1970.[9]

Technically, a blast furnace is capable of consuming larger percentages of scrap, but current economic incentives for doing so are minimal. Therefore, with appropriate incentives, the blast furnace represents an opportunity for more scrap-intensive steelmaking processes. However, some modification in blast furnace practice will be required.

Steel is produced by three major processes that convert pig iron, scrap, and fluxes into steel ingot. These processes use open-hearth, basic-oxygen, and electric furnaces. The ingots are then further processed into steel-mill products, or the hot metal is

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fed to continuous casting units which produce intermediate shapes for further processing in the mills.

Open-Hearth Furnace.   Because of the long production times required to convert iron to steel in the open hearth, its use has declined. In 1960, the open-hearth process accounted for 87 percent of total steel production, but in 1970, for only 36.6 percent (or 48.0 million tons).[10] This trend is likely to continue.

The open-hearth furnace is inherently capable of utilizing the full range of scrap charge from zero to 100 percent. We estimate that in 1970, open hearths consumed about 27 million tons of scrap, which corresponds to 56 percent of their output. But any shift toward more scrap-intensive steel-making practice is more likely to occur as a result of changes in blast-furnace and basic-oxygen practices and installation of electric furnace facilities, rather than from a return to open-hearth steel-making.

Basic-Oxygen Furnace (BOF).   Basic-oxygen furnaces, a more recent development, are an increasing factor in steel-making due to the much shorter time required to produce a "heat of steel". Basic-oxygen steel-making depends on the exothermic reaction between gaseous oxygen and a number of the constituents of the molten iron to provide the thermal energy required for converting pig iron to steel; no additional fuels are normally used. In this process, ferrous scrap is needed to absorb the excess heat generated, over and above that required to bring the steel to "tapping temperature." However, the amount of scrap which can be charged to the BOF is limited--the maximum under present practice is about 30 percent of each charge to a furnace. Because of the economies of its short heat time, the BOF process has grown appreciably, from 3.3 percent of total steel production in 1960 to 48 percent in 1970 (63.3 million tons).[10] Unfortunately, this has suppressed rather than promoted the use of scrap.

Actual scrap utilization in the BOF process varies, to the extent that scrap prices can compete with the cost of hot metal or pig iron from the blast furnace. Thus in 1970, about 21.1 million tons of the input (or 33.2 percent of the BOF steel output) was derived from scrap.[11] A number of technical approaches would allow more scrap-intensive BOF steel-making, if economic incentives develop. Examples are: (1) preheating of the scrap charge, (2) bottom-blowing, or injection of oxygen at the bottom of the vessel. These practices are now in varying stages of evaluation and commercialization.

Electric Furnaces.   Electric furnaces are designed to operate almost entirely on scrap. They are versatile and produce everything from high-quality specialty to low-quality structural steels. In integrated steel-making facilities, the scrap charge is largely internally generated (home scrap) from other steelmaking operations. In 1970, this process consumed 23 million tons of scrap to produce 20.1 million tons of steel products.[11] The additional scrap was required because of losses in the manufacturing process.

The electric furnace process has grown from 8.4 percent of total steel production in 1960 to 15.2 percent in 1970.[10] This process has considerable potential for increasing the use of ferrous scrap. A major factor controlling growth will be the cost of electric power required to melt scrap, particularly when this requirement is compared to new developments in the BOF steel-making process.

Electric furnaces are becoming more and more extensively utilized by the non-integrated steel-makers, who depend on purchased pig iron and scrap for their raw materials. Typical examples are the "mini-mills"--small steel-makers who purchase local scrap and produce mostly light structural steel products for a local market. The "mini-mill" approach may be a particularly promising one to convert ferrous scrap separated from municipal solid waste, because the steel products manufactured by this process can be sold to a local market.

Foundries depend to a great extent on scrap as the raw material, and both electric and cupola furnaces are used to melt the metal. The electric furnace is finding increasing use in foundries at the expense of cupola furnaces, partly because of air pollution problems associated with the latter. Shipments of steel and iron castings from the ferrous castings industry were 16.5 million tons in 1970.[12]

Scrap Utilization - Ferrous scrap is obviously an important raw material for the steel industry. The extent to which it is being utilized (or conversely, the extent to which ferrous scrap becomes solid waste) has largely resulted from an historic interplay of economic, technical, and political factors which have created the present structure of the steel industry.

In 1970, a total of 70.3 million tons of ferrous scrap was consumed by the steel industry in producing 131.3 million tons of raw steel (53 percent scrap). Of the scrap, 46.3 million tons (or 66 percent) was internally generated home scrap, and 24 million tons was purchased.[13] At a scrap generation rate of 20 percent in fabrication, 19.4 million tons was theoretically available as prompt industrial scrap; so that as a minimum, 4.6 million tons (or 6.5 percent of the total consumption of scrap) may have represented post-consumer scrap from obsolete sources. Of course, not all prompt industrial scrap was actually recycled, so that the contribution from obsolete scrap was certainly more than 4.6 million tons, perhaps 6.5 million tons is a more realistic value, or about 5 percent of the total steel produced.

The ferrous foundry industry is already highly scrap-intensive. We estimate that 15.9 million tons of scrap were consumed in the production of 16.5 million tons of products (96 percent scrap). Of this scrap, about 5.6 million tons (35 percent) was home scrap and 10.3 million tons (65 percent) was purchased scrap. Because only about 0.8 million tons was theoretically available as prompt scrap from metal castings users, most of the 9.5 million tons of purchased scrap could represent obsolete scrap. Thus, the steel and foundry industries together consumed an estimated 14 to 16 million tons of obsolete or first-consumer scrap in 1970.

Our data show that a total of 96.3 million tons of ferrous scrap was used in 1970.

Activity	Scrap Consumption (MM tons)
Steel industry	70.3
Foundry industry	15.9
Export (net)	10.1
Total	96.3

Disposal - Numerous studies have been made to determine the extent to which metals contribute to solid waste in the United States. Two approaches were taken. In one approach, collected municipal waste and litter were analyzed according to the type and amount of metal present. Battelle[14] has recently taken another approach to estimate the amounts potentially available for recycling. Their analysis of the volume of metal wastes available considers the service life and the consumption statistics for a given product. Not surprisingly, they found that the amount of metal waste theoretically available for recycling is higher than that which is actually visible as collected waste.

Much of the so-called uncollected wastes include industrial wastes, discarded automobiles and appliances, litter, etc., which are not necessarily collected by municipalities. Much of this waste actually is recycled.

The various estimates for the metal content of collected municipal waste range from 6 to 9 percent by weight, based on actual analysis, which represents about 12 to 18 million tons of metal scrap. While these fractions are not very large, metal wastes nevertheless constitute a highly visible portion, because they include metal cans and foils. Uncrushed, these cans are particularly troublesome, because they take up valuable space in a land fill.

Aluminum

The U.S. aluminum industry is divided into three major segments:

1. The integrated primary producers. Their principal business is converting aluminum ore (bauxite) to primary aluminum ingot. They also produce a variety of mill products and some industrial and consumer products and ship to foundries, manufacturers and other users of aluminum. This segment consumes both internally generated and purchased scrap. In 1969 about 19 percent of all scrap was consumed by this segment.

2. The non-integrated fabricators and foundries. This segment does not have ore conversion capability, and depends on the integrated producers and the secondary smelters for raw materials. They purchase primary and secondary ingot, billet, and/or scrap, and melt and fabricate it. The aluminum-casting industry is a major factor in this segment. In 1969 about 14 percent of all scrap was consumed by this segment.

3. The aluminum smelters. They remelt and refine aluminum scrap to produce secondary aluminum ingot, either for internal use or for sale to other non-integrated users of aluminum ingot. In 1969, about 67 percent of all aluminum scrap was consumed by this segment.

The total U.S. supply of aluminum ingots and products in 1970 was 10.8 billion pounds, with a value of about $5.2 billion.[15]

Scrap Utilization - Most of the aluminum scrap which is recovered and recycled flows through the traditional channels of the secondary metals industry; that is, through scrap dealers and brokers. About 1.6 billion pounds of aluminum was recovered in 1970, of which only 0.3 billion pounds was obsolete scrap.[16]

Scrap aluminum in the form of secondary ingot competes directly with primary ingot in the non-integrated segment of the industry. Generally, secondary is cheaper, but primary is preferred in all cases where a high level of purity is required.[17]

The smelters play an important role in secondary aluminum recovery; in 1970, they processed over 1.2 billion pounds of scrap into secondary aluminum ingot. About 87 percent was used by the metal casters; the remaining 13 percent was used by the steel industry for deoxidizing, and by the zinc and other industries for alloying.

Disposal - Aluminum is the only non-ferrous metal that occurs in significant quantities in municipal waste (about 0.5 percent on the average), but it is a very visible portion, because it appears as containers and general packaging (cans, foils, and trays). Many of these items appear as urban litter and are, therefore, especially insulting to the environment.

SELECTION OF SOLID WASTE REDUCTION OPPORTUNITIES

Initial Screening

We first compiled a list of most products made wholly or partly of metal purchased by the Federal Government, based on the Federal Supply Classification System (FSC). This list was reviewed and screened to eliminate those product groups which we did not recognize as important opportunities for solid waste reduction (Table 32). In this preliminary screening we used the following selection criteria, and products meeting these criteria were eliminated.

1. The product is purchased in small quantities by the Government; a small percentage of the public purchases it; and/or, it is now generally recycled or consumed and thus does not represent a highly visible portion of solid waste (Criteria A3, A4, B1, Table 8).

2. The product is highly sophisticated and complex, and the performance requirements demand that the construction materials and design meet rigid specifications with little latitude for modification. Therefore, secondary material cannot be used, and reducing the weight/volume of the product is questionable (Criteria C2 and C6, Table 8).

At this point, approximately 200 selected Federal and Military specifications for products within the remaining FSC groups were examined (Table 33). Specifications were selected either as being representative of a given group or class, or because they appeared to be promising solid waste reduction opportunities.

TABLE 32

METAL-CONTAINING PRODUCT GROUPS NOT CONSIDERED SOLID WASTE REDUCTION OPPORTUNITIES

End-use category	FSC no.	Product
Transportation	15	Aircraft; and airframe structural components
	16	Aircraft components and accessories
	17	Aircraft launching, landing and ground handling equipment
	18	Space vehicles
	20	Ship and marine equipment
	24	Tractors
	25	Vehicular equipment components
	28	Engines, turbines, and components
	29	Engine accessories
Ordnance	10	Weapons
	11	Nuclear ordnance
	12	Fire control equipment
	13	Ammunition and explosives
	14	Guided missiles
Communications and electric power equipment	58	Communication, detection and coherent radiation equipment
	59	Electrical and electronic equipment components
	63	Alarm and signal systems
Construction	43	Pumps and compressors
	44	Furnace, steam plant and drying equipment; and nuclear reactors
	46	Water purification and sewage treatment equipment
Heavy equipment, machinery, hardware	30	Mechanical power transmission equipment
	31	Bearings

Source: Arthur D. Little, Inc.

End-use category	FSC no.	Product
Heavy equipment (cont'd.)	32	Woodworking machinery and equipment
	34	Metalworking machinery
	36	Special industry machinery
	38	Construction, mining, excavating and highway maintenance equipment
	39	Materials handling equipment
	43	Pumps and compressors
	49	Maintenance and repair shop equipment
	51	Hand tools
	52	Measuring tools
	53	Hardware and abrasives
Office machines, equipment and supplies	36	Special industry machinery
	74	Office machines, visible record equipment and data processing equipment
Instruments	12	Fire control equipment
	49	Maintenance and repair shop equipment
	66	Instruments and laboratory equipment
	67	Photographic equipment
	69	Training aids and devices
	58	Communication, detection and coherent radiation equipment
Medical and recreation	65	Medical, dental and veterinary equipment and supplies
	77	Musical instruments, phonographs and home-type radios

TABLE 33

INITIALLY SELECTED PRODUCT GROUPS

FSC No.	Product
19	Ships, small craft, pontoon, and floating docks
22	Railway equipment
23	Ground effect vehicles, motor vehicles, trailers and cycles
35	Service and trade equipment
37	Agricultural machinery and equipment
40	Rope, cable, chain and fittings
41	Refrigeration, air conditioning and air circulating equipment
45	Plumbing, heating and sanitation equipment
47	Pipe, tubing, hose and fittings
48	Valves
54	Prefabricated structures and scaffolding
56	Construction and building materials
61	Electric wire and power and distribution equipment
71	Furniture
72	Household and commercial furnishings and appliances
73	Food preparation and serving equipment
81	Containers, packaging, and packaging supplies
85	Toiletries
89	Subsistence
95	Metal bars, sheets and shapes
96	Ore, minerals and their primary products

Secondary Screening

In general, the selected product specifications fall into three categories.

1. A packaging material where the Government does not specify the type of metal packaging. Typical examples in this category are many subsistence items that are purchased "off the shelf," or as level "C" packaging (see Section I). The selection of the type of metal container is usually left to the supplier. This category can represent an important solid waste reduction opportunity, because packaging materials are a highly visible portion of the solid waste stream and are purchased by most of the population.

2. A non-packaging material specification that is developed by the manufacturer. A prime example is the passenger car.

   Interim Federal Specification KKK-A-00811L (October 30, 1971), Paragraph 3.3, makes only the following reference to materials in the automobile:

   "Materials. The materials shall be new and not less than the quality conforming to current engineering and manufacturing practices. Materials shall be free from defects and suitable for the intended purpose."

   The automobile manufacturers, of course, select materials based on specifications; some are generated internally while others are generated in cooperation with the Society of Automotive Engineers (SAE) and the American Society for Testing and Materials (ASTM). These specifications have evolved over the years, and extensive research would be required before they could be modified in the interest of reducing solid waste, whether by recommending products of lighter weight or with a specified concentration of secondary material. Therefore, these items generally were not considered opportunities.

   Much of the metal in the passenger automobile is "new" only in the sense that it has been remelted or re-refined. In fact, the metal contains large amounts of secondary material of adequate purity. Also, no material is completely defect-free; the intention of this Government specification is apparently to require that the nature and number of defects be economically consistent with the necessary product performance.

3. The specification for the product is a performance specification. In this case, the product must meet a variety of physical, chemical, and mechanical tests. In general, these specifications tend to be spelled out in detail, particularly in military specifications. Many of these incorporate or reference specifications written by non-federal groups, such as the American Iron and Steel Institute, the Society of Automotive Engineers, the Air Conditioning and Refrigeration Institute, ASTM, and the Underwriters Laboratories (UL). Again, these performance specifications have evolved over a period of time, and extensive research would be required before they could be modified in the interest of reducing solid waste. Thus, these products also are of limited interest as opportunities.

None of the examined specifications for metallic products states that secondary materials may or may not be used.

Because the materials specifications in Federal and Military standards for metal products are generally performance specifications, little opportunity exists for the immediate modification of these specifications to reduce solid waste. Government, industry, and the consumer will have to work together in an extensive research and evaluation program, for each specific product considered a potential opportunity, to determine if the standards for that product can be modified to meet the objectives of this study. Generally, it will mean reducing the performance requirements; but in many instances the costs of modifying the specification will not be warranted, because the benefits in terms of reducing solid waste are questionable.

Potential Solid Waste Reduction Opportunities

The most promising products, where a re-evaluation of specifications may be warranted, are those that are homogeneous (fabricated from one material) and do not have to meet very stringent performance requirements. Examples include construction-grade steel and aluminum and some of the large-volume products that are fabricated from these metals. A very significant metallic product is the packaging container, because it represents an important fraction of the solid waste stream.

Packaging Materials - Recognizing that metal packaging is an important solid waste reduction opportunity area, the question then is "What should the Federal Government specify?" A number of approaches are possible.

Because packaging materials are often composites containing more than one material, the Government could introduce new specifications to substitute homogeneous packaging materials for composites. For example, soft drinks and beer that are purchased in tinplate cans could be purchased in tin-free steel or all-aluminum cans, all-plastic, or all-glass containers.

This approach would make the products more recyclable. But this is an advantage only if a separate collection system is available, and a sufficient demand exists for the secondary material.

Of all the materials cited above, steel is the only one that is being separated from mixed solid wastes today, because it can be separated magnetically. Aluminum is currently separated as cans in special collection centers. More extensive recovery of these materials awaits economical mechanical systems.

Another approach, consistent with the objectives of this study, is to specify the use of the lightest-weight containers that are commercially available.

The packaging industry is always striving to develop new technology in this area. For example, a recent development has been the introduction of a seamless steel (tinplate) beverage can. This product has thinner sidewalls, and is lighter in weight than the conventional side-seamed steel can (see below).

Still another approach might be to specify the use of secondary material in the container. This strategy must take into account the availability of the secondary material, various technical factors, and the structure of the industry.

In the section that follows, we explore each of these alternatives and their impact on the economy and the generation of solid wastes. First, let us consider the future of the metal container in the absence of any change in Government procurement policy.

THE METAL CAN--BASELINE FORECAST

Types of Cans

The tin can has come a long way since 1809. Today's cans come in many different sizes, shapes, and materials, and the method of manufacture varies.

All-Tinplate Three-Piece Can - Historically, the tinplate can has been the standard type of metal container. Most tinplate is made by electrolytically coating steel with a thin coat of tin. Various steel thicknesses and tin-coating thicknesses are used, depending on the product being packed. The primary purpose of the tin is to act as a base for the high-lead solder used to form the hermetic side seam of the can body. The tin also serves to protect the steel from atmospheric corrosion. (Most tinplate cans now employ internal organic coatings to prevent reaction between the can contents and the tinplate.) In manufacturing, the two tinplate ends are double-seamed onto the can body with a sealant.

Tinplate Can with One "Easy-Open" Aluminum End - This is similar to the all-tinplate can, but has one aluminum end that is scored and carries an "easy-open" tab. The market for this can is primarily soft drinks and beer.

Tin-Free Steel (TFS) Three-Piece Can - Because of the high cost of tin, and increasing competition from aluminum and glass containers for the soft drink and beer markets, the steel and can-making industries developed a container made from tin-free steel. This steel has a thin coating of chromium oxide that protects the steel from corrosion during manufacture of the cans. A hermetic side seam is formed on the can body by adhesive bonding or welding, and the can ends are attached in the normal manner. Organic coatings are used to protect the inside of the can from corrosion. Most of these cans are used in the soft drink and beer market and have one aluminum "easy-open" end.

The steel costs about 10 to 15 percent less than tinplate and offers a cost saving to the packager of about $2 per thousand cans. It is more suited for high-volume production markets (long runs of the same can size) typified by the needs of the soft drink and beer industry, rather than for the more fragmented markets of the food industry. At the present time, these cans cannot be made by users, because the patents are held by the merchant suppliers.

The All-Aluminum Can - This can is constructed of two, rather than three, pieces. The side and bottom are formed from aluminum sheet by the draw-and-iron process. In this process, aluminum blanks are cut from sheet and formed into cups and then formed through a series of concentric ironing dies. The primary purpose of the ironing is to make thin side walls where minimum strength is required, without thinning the bottom where maximum strength is needed. The top of the can body is the second piece, and it is attached in the normal manner after filling the can.

The all-aluminum can has the advantage that it is lighter than the equivalent steel can (about 40 pounds per thousand versus about 100 pounds per thousand for the standard 12-ounce container), so that shipping costs are lower. The contents also chill more quickly in the all-aluminum can than in the steel can. These advantages tend to offset the slightly higher cost of the all-aluminum cans.

The Two-Piece Steel Can - This is a recent development that is in the early stages of commercialization. The sides and bottom of the can are also formed by a draw-and-iron process similar to that for the all-aluminum can, and the top is attached after filling in the normal manner. This can was designed to reduce material cost by having a thick bottom and thin sidewalls.

With the present state of the technology, the draw-and-iron, two-piece can requires a thin coating of tin on the steel to act as a lubricant during the metal-forming process. However, development work is under way on forming methods and lubricants that should eliminate the tin. Then, with the tin eliminated, recyclability should improve.

Production by the Steel Industry

In 1970, the steel industry shipped about 7.8 million tons (or about 8.6 percent) of its shipment of mill products to the container and packaging industry.[18] More than 5.6 million tons were consumed by the metal-can industry.[19] Thus, the can industry is a very important market for steel. Soft drinks and beer account for a large portion of the can market (40 percent of the can shipments in 1970). However, steel's share in the soft drink and beer can market is expected to decrease from 86 percent in 1970 to about 60 percent by 1985; the decline would have been more drastic if the TFS can had not been developed.

As mentioned previously, tin-free steel costs less than tinplate, and we believe that this cost saving will allow steel to remain competitive with alternative beverage packaging materials. From the steel industry's point of view, the shift from tinplate to TFS is therefore necessary for this market. While steel's share of the beverage can market is expected to decrease because of the inroads made by aluminum, we estimate that the total market for steel beverage containers, including tinplate and TFS cans, will increase from 27 billion cans in 1970 to 35 billion in 1978 and 40 billion in 1985 (Table 34).

Normally, market estimates for materials consumption are based on 25.3 base boxes per ton of steel, which is the average value for all cans. (A base box is an area of 31,360 sq. in., equivalent to 112 sheets 14 in. x 20 in. in size.) But most of the soft drink and beverage cans are made from "double-reduced" sheet (6-mil stock) that weighs about 55 pounds per base box, which is equivalent to 36 base boxes per ton of steel. Therefore, the steel consumption values in Table 34 were calculated based on the latter figure.

In 1970, about 1.4 million tons of scrap steel from spent beverage cans were discarded. The volume is expected to rise to about 2 million tons in 1985 (Table 34), assuming that all cans consumed in each of these years are discarded in the same year. The difference between the values shown in the table for steel consumed in can-making and the steel in cans represents the scrap steel generated during can-making, most of which is recycled or consumed by the copper precipitation industry.

Production by the Aluminum Industry

Approximately 1.5 billion pounds (750,000 tons) of aluminum were shipped to the packaging industry in 1970. This represents 14.5 percent of the total domestic aluminum shipments of 10.1 billion pounds. Of the 1.5 billion pounds used in packaging, about 900 million were consumed by the can manufacturing industry for can bodies and ends.[8]

Considerable scrap is generated during the manufacture of all-aluminum cans, but most of it is recycled. We estimate that over 250 million pounds of all-aluminum cans were shipped in 1970. This represents a significant potential additional source of aluminum scrap, considering that about 300 million pounds were recovered from all old aluminum scrap sources in 1970.[20]

All-aluminum cans are manufactured by some of the primary aluminum producers, the major merchant can manufacturers, and by at least one brewery. Alcoa has developed the technology for manufacture of even lighter-weight all-aluminum cans but at present intends to license this technology, preferring to remain a major supplier of can stock and can ends to can manufacturers.

Production by the Tin Industry

In 1970, the United States consumed approximately 82 thousand tons of tin, of which 23 thousand tons were secondary. The secondary tin includes over 2.8 thousand tons that were recovered from tin mill and can manufacturer's scrap. During that same

TABLE 34

ESTIMATED CONSUMPTION OF STEEL BY THE SOFT DRINK AND BEER INDUSTRIES

Year	Type†	Number of cans (billions)	Weight of steel in cans (MM tons)‡	Steel consumption (MM tons)§
1970				
	TFS	10	0.50	0.56
	TP	17.3	0.87	0.98
	Total	27.3	1.37	1.54
1978				
	TFS	30	1.50	1.69
	TP	5	.25	0.28
	Total	35	1.75	1.97
1985				
	TFS	38	1.90	2.14
	TP	2	.10	0.11
	Total	40	2.0	2.25

Source: Arthur D. Little, Inc.

† TFS - Tin-free steel
TP - tinplate

‡ Based on 100-lb. of steel per thousand 12 oz. cans

§ Based on 36 base boxes per ton, 500 cans per base box year, can production consumed approximately 20 thousand tons of tin in tinplate, or 24 percent of total tin consumption. Tinplate is made from primary tin, which is imported. The average price in 1970 was $1.74 per pound.[21]

The use of tin for packaging has been declining as a result of two factors:

1. Thinner tin coatings are being used for packaging. The tin in tinplate has decreased from 11.7 pounds per ton in 1964 to 10.1 pounds per ton of tinplate in 1969.[22]

2. The largest and fastest growing segments of the canning industry--beer and beverage--have elected to use alternative types of containers, such as TFS, aluminum, and glass.

We predict that the consumption of tin by the beer and beverage market will decrease by about 3.2 thousand tons (11.5 percent of 1970 primary tin consumption) during the period from 1970 to 1985.

Industry Structure - The metal can industry consists of over 100 companies who operate 299 plants with 68,000 employees.[23] The major metal can production areas are the East-North-Central, Pacific, and Middle-Atlantic regions.

The can industry is very concentrated. In 1970, only two companies--American Can and Continental Can--accounted for 56 percent of the value of all can production, and 67 percent of all merchant can sales. The total merchant sales of metal cans in 1970 amounted to $3.4 billion.

At least 30 firms make cans solely for their own use. These include such well-known food processors as Borden, Campbell Soup, Carnation, General Foods, and others. But since 1964, captive production of cans has declined. In 1970, only 18 percent of all can production was captive. This decline in captive share is due to the increasing importance of aluminum and tin-free steel cans.

Markets - Shipments of metal cans in 1970 amounted to 69.3 billion cans (Table 35). These figures, both in terms of base boxes and billions of cans, are probably low because they were developed in cooperation with the manufacturers' association, which represents only about 90 percent of the producers. Other estimates have placed the total at 76 billion cans.[24] Virtually all the cans, other than those for soft drink and beer, were tinplate.

TABLE 35

CAN SHIPMENTS (1970)

	Thousands of base boxes metal consumed†	Billions of cans‡	Percent of total cans
Fruit and fruit juice	13,337	5.35	
Vegetable and vegetable juice	24,058	9.65	
Evaporated and condensed milk	2,534	1.26	
Other dairy products	585	0.34	
Meat, including poultry	3,723	1.62	
Fish and seafood	3,450	2.03	
Coffee	3,766	0.85	
Lard and shortening	1,733	0.30	
Baby food	1,053	0.67	
Pet food	6,524	3.26	
All other food, including soups	14,024	5.40	
Total food	74,787	30.73	44
Soft drink	26,197	13.10	
Beer	37,593	18.80	
Total beverages	63,790	31.90	46
Oil	3,108	0.84	
Paint and varnish	4,886	0.85	
Antifreeze	816	0.12	
Pressure packing (valve type)	5,431	2.36	
All other non-food	6,481	2.50	
Total non-food	20,722	6.67	10
TOTAL	159,299	69.30	100

Source: Bureau of Census, U.S. Department of Commerce, Containers and Packaging, October 1971

†A base box is an area of 31,360 square inches, and equivalent to 112 sheets, 14 inches by 20 inches in size

‡Arthur D. Little, Inc., and the Can Manufacturers Institute, Inc., estimates

Food Cans - In the face of competing packaging systems, we expect the food-can market to grow little, if at all, between 1970 and 1978. Shipments of cans for food will probably even decline slightly, from 30.7 billion units in 1970 to 30.5 billion units in 1972. An optimistic estimate of shipments in 1978 is only 35 billion cans, which represents an average annual growth of about 3 percent from 1972 to 1978. Growth of this segment from 1978 to 1985 is expected to continue to be slow, to perhaps 40 billion units by 1985.

While tin-free cans will be satisfactory for most food products from a technical standpoint, we expect very little shift from tinplate to TFS cans in this segment of the market during the period 1972 to 1985 for the following reasons. At least 30 food canners have their own can-making facilities that are not equipped for TFS seaming, which was developed by the merchant can makers and not the canners. Further, canners generally must contend with a large variety of can sizes, and many tinplate lines exist to make these cans. TFS cans rust and so must either be coated externally or lithographed. Lithographing is usually not a wise course for food canners, who often do not know what label will be required. Although incremental savings can be achieved by using TFS cans, the capital investment needed is so high that the changeover will be slow. However, the use of TFS can ends requires little changeover, and some of the manufacturers have already begun to use them. But, this approach does not solve the solid waste problem, because the tinplate body is still used.

We believe that the food industry will be slow to convert their can lines from tinplate to TFS. This conversion, if it does occur, will start with those cans that are used in large volume, namely, the No. 300, No. 393, No. 2, No. 2-2/12, and the No. 10 can. The products contained in these cans might be tomato juice, tomatoes, peaches, apricots, etc. Low-acid products, such as soups, meats, pet food, etc., could be canned in TFS, if the merchant can companies would license the TFS side-seam technology to the food companies, or if the food canners would purchase TFS cans from the merchant can makers. The key to any conversion, then, really lies in the relationship between the two large merchant can companies, and the large food companies that manufacture their own cans.

We estimate that the maximum portion of the food market which might be captured by the TFS can by 1978 is 10 percent of the market, or 3.5 billion units. Increased penetration by the aluminum can into this market is also expected. It is unlikely that more than 15 percent of the food market, or 6 billion cans, will be two- and three-piece tin-free steel cans by 1985, unless the Government intercedes.

Beverage Cans - The spectacular growth of the use of cans in the soft drink and beer markets over the past decade is not expected to continue, because this market is gradually becoming saturated. The beverage can will continue to be the fastest growing segment of the can industry, even in the period from 1978 to 1985, but there will be a continued erosion of the market shared by tinplate in the face of competition from tin-free steel and aluminum.

We estimate that soft drink and beer can shipments will increase from 31.9 billion cans in 1970 to about 50 billion in 1978, and perhaps to 65 billion units by 1985 (Table 36). During this period (1970 to 1985), shipments of tinplate cans as a percentage of all beverage cans will decrease from 55 percent to possibly as low as 3 percent.

For many reasons, including expected changes in technology, estimates of the total market for beverages and the market share by each type of can are difficult to make for a time frame that includes 1985. In our forecast, we have assumed a certain rate of change due to emerging technologies in can manufacture and trends in recycling.

Today, the principal technology for manufacturing the two-piece steel can requires a thin tin coating as a lubricant in the metalworking process for forming the can body. While this can is 25 percent lighter than its three-piece steel counterpart, the pressure of increasing tinplate prices is certain to result in continued efforts to develop drawing lubricants and techniques for tin-free steel. Successful development of this technology is likely and has been assumed in our projection of the decline in the consumption of tinplate steel for beverage cans.

The predicted continued growth of the all-aluminum can is based on the assumption that the $200 per ton paid for cans at the reclamation sites will motivate sufficient recycling to prevent this commodity from becoming identified as an ecologically undesirable package. However, large-scale recycling of all-aluminum cans will depend on the widespread adoption of technology for separating the metal from the mixed solid waste.

Can Collection - About two years ago, an effort was begun in the United States to channel scrap from the consumer into the well-developed metal recyling system. Most present programs involve a collection-center approach that is highly labor intensive and, therefore, we believe this offers only an interim solution.

TABLE 36

ESTIMATED CONSUMPTION OF BEVERAGE CANS BY TYPE (1970 - 1985)

Type can	1970 Billions of cans	1970 %	1972 Billions of cans	1972 %	1978 Billions of cans	1978 %	1985 Billions of cans	1985 %
Tinplate	17.3	55	10.5	29	5	10	2	3
TFS	10	31	18	49	30Ψ	60	38Ψ	58
All-aluminum	4.6	14	8	22	15	30	25	39
Total	31.9	100	36.5	100	50	100	65	100

Source: Arthur D. Little, Inc.

Ψ Includes two-piece draw-and-iron steel can.

Steel. While the major steel companies have stated a willingness to recycle all discarded steel cans, so far only token amounts have been recovered and recycled by the steelmakers. However, steel cans can be recovered from mixed solid waste. According to the American Iron and Steel Institute, about 1.5 billion cans were recovered from solid waste in 1971, primarily by magnetic separation. Can scrap is very low quality obsolete scrap. But the shift from tinplate to tin-free steel cans should increase the quality of can scrap and allow more can scrap to be charged in a furnace.

Based on the estimated weights of steel cans to be produced, the projected shift from tinplate to TFS will result in a substantial decrease in lead and tin impurities in beverage-can scrap (Table 37). For example, in 1970 this scrap was contaminated with a total of 1.36 percent lead and tin; in 1985, we expect the impurity level to drop to 0.11 percent. These estimates were derived by considering that a ton of the typical aluminum-lid, tinplate beverage can has 36.8 pounds of lead and 814 pounds of tin.[25] Though the trend from tinplate to tin-free steel will clearly improve the recyclability of steel cans used by the beverage industry, the steel beverage cans in ferrous solid waste are still mixed with those from the food industry, which contain most of the tin consumed by the can manufacturers.

Aluminum. Recycling of the all-aluminum can at present depends only on the reclamation center approach, because aluminum is not magnetically separable; though the technology for recovering this metal from mixed solid waste is available, it is not yet widespread. Industry sources estimate that approximately 750 million cans were collected in 1971. This is more than 12 percent of the estimated 6 billion all-aluminum cans shipped in 1971.[26,27] In some areas, collection rates approached 50 percent. A primary reason for this success is the high price ($200 per ton) paid to the consumer for scrap aluminum cans at the reclamation centers.

Recycling of aluminum cans has required the development of nontraditional recycling channels. Cans are presently made from aluminum alloys that have a high magnesium content but the smelters' primary market for secondary aluminum ingot is for casting alloys, which require a low magnesium content. Aluminum with a high magnesium content requires additional refining, and, under present technology, this increases the cost of producing secondary ingot. Another major cost, which is likely to increase, is that associated with the need for air-pollution control equipment at the smelter. The present trend, which seems likely to continue, is to return the discarded cans not to the scrap

TABLE 37

PROJECTED CHEMISTRY OF BEVERAGE CAN SCRAP (1970 - 1985)*

		Tonnage of scrap cans			Percent of lead and tin in all beverage can steel	
Year	Type can	Millions of tons of steel	Thousands of tons lead	Thousands of tons tin	lead	tin
1970	Tin-plate	0.87	15.50	3.60		
	TFS	0.50	-	-		
					1.10	0.26
1978	Tin-plate	0.25	4.60	1.05		
	TFS	1.50	-	-		
					0.26	0.06
1985	Tin-plate	0.10	1.8	0.42		
	TFS	1.90	-	-		
					0.09	0.02

*Source: Arthur D. Little, Inc., estimates smelters but to the primary producers, where they are converted into new can stock. Today, however, some of these cans are recycled as secondary ingot.

The number of all-aluminum cans reclaimed via collection centers is likely to grow in the near future; however, we believe that significant recovery rates for aluminum cans will depend on the widespread adoption of new technology for mechanically separating this metal from mixed solid waste. Aluminum's inherent value will serve as an impetus to implementing such technology.

Markets for Can Scrap - As noted previously, aluminum-can scrap has a ready market, but steel-can scrap is another matter. The tin impurities in the latter represent a problem to the steelmakers because it degrades furnace refractories, forms hard spots in the steel that make steel rolling difficult, and results in a final product which is brittle and has poor surface quality. Therefore, only low concentrations of can scrap can be used in a furnace. However, as the concentration of tin in can scrap is gradually reduced, with the growth of the TFS can market, the problem will be less significant. Nevertheless, TFS can scrap is still of lower quality than much of the available obsolete scrap. Currently, the National Steel Company and the Carbonated Beverage Container Manufacturers Association are experimenting with TFS can scrap to convert it to lower-grade steel. This type of program should be supported.

Looking ahead to 1985, Battelle[28] estimates that total domestic ferrous scrap requirements will increase from 94.3 million tons in 1969 to 141.4 million tons in 1985--an increase of 49 percent--while the production of raw steel and castings is anticipated to grow only 42 percent, to 200 million tons. Battelle expects that during this period purchased-scrap requirements will grow from 36.9 million tons to 61.4 million tons. This will require an increasing fraction of obsolete scrap. If the availability of prompt industrial scrap also increases at the 42-percent rate, then the requirements for obsolete scrap might increase by almost 10 million tons by 1985. This does not, of course, imply a ready market by 1985 for 10 million tons of ferrous solid waste, nor even of the discards of the estimated shipments of 1.9 million tons of tin-free steel in soft drink and beer cans. Demand for ferrous scrap must be increased by considerably more than an additional 10 million tons by 1985, if a significant portion of ferrous solid waste is to be utilized.

We expect that very little ferrous solid waste will be utilized, despite the quality improvement which will result from the use of tin-free steel in containers. Additional scrap requirements in 1985 will be met by tapping the traditional sources of higher-grade material, as well as imports, unless new Government programs are implemented, and new applications are found for the lower-quality steel scrap.

The Copper-Precipitation Industry. At present, the copper-precipitation industry represents the only significant market for obsolete cans. This market is limited to the western part of the United States, and consumes about 500,000 tons of high-surface-area ferrous scrap annually. Of this, over 100,000 tons are derived from processed obsolete cans, mostly separated magnetically at a limited number of municipal disposal sites. The remainder of the ferrous scrap consumed is can-manufacturing scrap and detinned can scrap obtained from detinners.

Obsolete can scrap obtained from a dump is purchased by a nearby processor for $15 per ton (delivered). The processor then incinerates, further shreds, and magnetically separates the ferrous portion, which adds approximately $20 per ton to the cost of the scrap (including his margin). Shipping to a copper smelter costs about $20 per ton, so that the copper-precipitation industry pays a total of about $55 per ton for the material.

The metallic impurities in the scrap after incineration do not affect its use for copper precipitation. The processors can, therefore, use all types of steel cans. In contrast, even after processing, the quality of a scrap does not make it acceptable to the steel industry for remelting (under present industry conditions), unless it is used in a furnace at very low concentration levels.

The market for copper-precipitation scrap is expected to grow to about 1 million tons by 1978, and then peak at 1 to 1.5 million tons by 1985. At present prices, this represents a market of $55 to $80 million per year, but this market is very limited. The predicted decrease in tinplate for soft drink and beverage cans will have no effect on this market, because both tinplate and TFS cans are acceptable. Thus, a sufficient source of supply of steel cans of all types is assured to meet the needs of the copper industry.

As the tin and lead content of steel cans decreases, a processor who supplies the copper industry may also be able to serve additional markets, providing the demand for ferrous scrap increases. Processors would be interested in new markets, because copper-precipitation scrap must be shipped in loose form, which is costly. Compacted scrap, the form desired by the steel industry, is less costly to transport.

Detinning Industry. Tinplate scrap is recycled by the detinning industry, which in 1970 recovered 2,608 long tons of tin and its compounds.[27] The treated scrap was almost entirely clean scrap purchased from tin mills and can manufacturers.

The detinners are only now beginning to process obsolete cans. At present, these are primarily all-tinplate cans obtained through reclamation centers. The industry has also announced plans to process mixed ferrous cans separated magnetically from mixed waste. Factors that will impede this development are the decreasing tin content of steel-can scrap and the widespread use of easy-open aluminum ends. Aluminum is an undesirable contaminant in the detinning process.

Despite rising tin prices, the technology and economics of detinning are becoming more unfavorable, as the recovery of tin from tinplate scrap decreases: 9.6 pounds per long ton of scrap in 1965, versus 7.6 pounds in 1970.[28] This decrease in tin recovery has occurred not only because the tin content of tinplate containers has been decreasing, but also because the market for tinplate has been decreasing. During the period from 1970 to 1985, assuming that 20 percent scrap is generated in producing tinplate cans, the anticipated decrease in tin from tinplate scrap available from the makers of beverage cans will amount to 850 cans (Table 38). The estimates given in Table 38 were made assuming the 1970 recovery rate of 6.9 lb. per ton of scrap.

THE METAL CAN--IMPACT OF ALTERNATE RECOMMENDATIONS

Specification of Tin and Lead-Free Metal Containers

If the Government specifies tin-free and lead-free containers (this could be TFS, steel, or all-aluminum cans) for those purchases now packaged in tinplate cans, such action will have a primary effect on the food and beverage processors. Usually, the Government purchases canned subsistence items directly from the processors; only rarely are these items purchased from a wholesaler.

The Possibilities of a "Ripple" Effect - Although a number of food processors manufacture their own cans (about 30 to 50 percent, according to an earlier study by the contractor), most beverage processors purchase their cans from can manufacturers. Therefore, when the Government buys canned beverages, the beverage supplier is, in most cases, not responsible for manufacturing the specified

TABLE 38

ESTIMATED TONNAGE OF TIN AVAILABLE FROM THE PRODUCTION OF TIN-PLATE BEVERAGE CANS (1970-1985) †

Year	Tons of tin-plate scrap from production of soft drink and beer cans	Tin available (tons)
1970	280,000	960
1978	80,000	275
1985	32,000	110

Source: Arthur D. Little, Inc.

†Assumptions - 6.9 lb. tin/ton tin-plate scrap
- can production generates 20 percent scrap

packaging though he does select the package and set the specifications. As indicated in Section I, this form of purchasing by the Government is desirable because it can promote a "ripple" effect.

Considering that the Federal Government purchases only a very small percentage of all subsistence products produced in the United States (normally less than one percent of the domestic output of a particular product), changes in the specifications of the packaging for these products would have a negligible effect on the reduction of ferrous metal wastes. Thus, the increase in quality of ferrous solid waste would be negligible, even if it were technically possible for the processors to package all Federal subsistence purchases in tin-free and lead-free containers. Because the Government purchases so little, the food processors would not make the capital investments necessary to produce their own TFS containers, even if they were licensed by the can manufacturers. However, some food processors might respond to the Government's action by using TFS containers (purchased from the merchant can makers) on the assumption that they could capture a significant portion of the Government's purchases for a specific subsistence item; but this is very speculative.

However, it must be recognized that any change in purchasing policy which introduces a new packaging specification for a container that is believed to be ecologically attractive may be interpreted as a Government "stamp of approval," and the "ripple" effect could be significant. In this case, canners who purchase cans would very likely request the can makers to meet the Government specifications, whether or not the product was sold to the Government. This would avoid costly "double stocking." And, most significantly, if the Federal Government's action were well publicized, public pressure would be applied to food retailers to purchase in "Government approved" packaging.

Need for Auxiliary Specifications - The purpose of this recommended specification change is to upgrade the quality of ferrous solid waste. However, this action alone will not guarantee a market for the ferrous scrap. As we have discussed, many current specifications for commodity products (that do not have to meet stringent performance specifications) will have to be carefully reviewed and tested to determine just how much and what type of metallic impurities are permissible. Only in this way will new markets develop for recovered, upgraded ferrous scrap from metal containers. Otherwise, the recommendation could have a negative impact on the secondary metals industry, which is currently unable to sell all the higher-quality ferrous scrap, because the market is limited.

Impact on Can Makers - As discussed earlier, the beverage industry is rapidly changing over from the tinplate can to TFS and the all-aluminum can. Thus, the recommended specification change will have little effect on this segment of the industry. The rate of change indicated in the previous section may be increased only slightly. The rate depends on how fast the can manufacturers can introduce new TFS and aluminum facilities and convert some of their old tinplate lines. Apparently, some companies are also ordering new lines for the two-piece steel can.

More significantly, the recommended specification change may spur the market growth of tin-free steel as a replacement for tinplate in other segments of the can market (such as the food market), if the specification is well publicized and the industry knows that the specification will be introduced when the packaging becomes available. Technically, the food processors can use TFS today; internal organic coatings have been developed which are suitable for many foods, and research in this area continues. Tin-free steel will probably first replace tinplate for those foods where suitable coatings are available and the market volume is large enough to justify installing new TFS can lines or converting old tinplate lines. Even with this Government incentive, we do not expect a decline in the use of tinplate in food canning to the extent expected in beverages.

This recommended change will not disrupt the can industry in any major way. As the market served by the food industry grows, new canning lines will be needed; the intention of the recommendation is to convince can makers to introduce tin-free canning lines as early as possible.

Impact on Basic Raw Material Producers - If the necessary research is done to develop new markets, the ferrous metal scrap industry will grow, the steel industry will become more scrap intensive, and more steel products will contain high concentrations of recycled material.

The recommended change will have little effect on the rate of growth of the aluminum can market because aluminum is continuing to penetrate this market. As the use of tinplate declines, TFS and all-aluminum will compete as replacements. The recommended change does not favor aluminum over steel. We believe that both should continue to compete. The detinners, of course, would be greatly affected by the recommended change. However, the decline in this business is already under way.

Impact on Exports and Imports - The United States is presently a net exporter of ferrous scrap: approximately 10 million tons exported in 1970. If the recommendations are successful and a more scrap-intensive steel industry is created, exports would be reduced. On the other hand, reducing the production of tinplate will reduce imports of tin because virtually all primary tin is imported. In 1970, about $70 million worth of tin used for tinplate was consumed by the can industry. Thus, the net effect of the recommended change on the "balance of payments" should be minimal.

Impact on the Generation of Solid Wastes - If the recommended specification changes are completely effective in achieving a higher-purity ferrous scrap, which could be collected and sold, then over 5 million tons of ferrous wastes derived from discarded cans could be recycled today, and about 8 million tons in 1985. This tonnage is equal to about one-third of the total tonnage of ferrous wastes. More realistically, however, these recommended changes would make about 2 million tons of steel can scrap available today, and 4 million in 1985.

An Alternate Specification Change

We also considered the possibility of specifying the use of only one type of container, rather than a mixture of tinplate, steel, aluminum, glass, and plastic containers, assuming that it was technically possible. However, without a thorough study, we cannot unequivocally state which of these materials is the most desirable solid waste. Furthermore, because the Government purchases of food and beverages are miniscule, in comparison with the total U.S. domestic output, many of the canners and bottlers probably would not respond to the Government request for a bid, because they could not afford to change their packaging lines so drastically just to satisfy the Government's specification change.

IV. GLASS

AN OVERVIEW

The glass industry consists of producers of containers, flat glass, and pressed and blown glass. On a production weight basis, containers dominate the glass industry and account for 70 percent of all glass production. The glass container segment consists of about 40 companies with 112 plants in 27 states in most regions of the country.[29] In 1971, the total employment in the glass container industry was 74,300, and the value of shipments was $1.9 billion. The four largest companies in this segment of the industry account for about 60 percent of the total shipments.[30]

Glass container manufacture is a fully integrated process. Most manufacturers start with basic raw materials and end with the finished product as the same location. For the most part, glass containers are not produced by food processors because glass plants are very costly and their production volumes are higher than the needs of an individual food processor. For example, a plant with two furnaces and six forming machines requires an investment of $8.4 million.[31]

Domestic shipments in 1970 were about 265.4 million gross, or about 38.2 billion containers (Table 39). Of these, food, soft-drink and beer containers accounted for more than 77 percent of all glass container shipments in 1970 on a unit basis, and soft drink and beer containers alone accounted for about 46 percent. In 1970, the returnable bottle accounted for 11 percent of all soft drink and beer containers, and about 5 percent of all glass containers, About 65 percent of all glass containers are clear glass, and 35 percent are colored.[32]

Cullet Utilization

Glass that is recycled is called cullet and is conventionally used as part of the raw material input in the glass-making process. To be used in container manufacture, cullet must be clean, free of metallics (such as ferrous and aluminum alloys), and only one color.

Most of this scrap is generated internally at a glass container plant, but according to Midwest Research Institute[33] about 4.5 percent is also purchased from bottlers and cullet dealers. In recent years, cullet utilization by the container industry has averaged about 15 percent of the melting furnace charge.

TABLE 39

DOMESTIC SHIPMENTS OF GLASS CONTAINERS (1970) †

Product Packaged	Billions of Units	Percent of Total
Food	12.1	31.6
Medicinal and health	3.3	8.7
Chemical, household, and industrial	0.5	1.4
Toiletries and cosmetics	1.7	4.4
Soft drink		
Returnable	1.6	4.3
Non-returnable	8.5	21.9
Beer		
Returnable	0.3	0.9
Non-returnable	7.2	19.0
Liquors	2.0	5.2
Wine	1.0	2.6

Source: Bureau of the Census, U.S. Department of Commerce, Containers and Packaging, October 1971

† Totals may not add because of rounding

Utilization varies widely--from 8 to 100 percent by weight.[33] It is technically feasible to utilize large fractions of cullet, and the members of the Glass Container Manufacturers Institute (GCMI) have set a goal of 30 percent.

Until recently, the only means for diverting discarded glass containers from the solid waste stream to cullet has been through the collection-center approach. According to GCMI, glass containers were being recycled at a rate of 192 million units per year by the end of 1971.[34] This was approximately 2 percent of the estimated container-glass production in 1971, and falls far short of the amount required to meet the 30 percent goal.

Without new technology and Government incentives, the collection-center approach is not likely to develop the supply level required for the 30-percent cullet goal. Today, under Government and industry sponsorship, this technology is being developed for removing, sorting, and cleaning the glass fraction from mixed solid waste. One example is the operation at Franklin, Ohio, which can separate the glass and aluminum fraction by the wet pulping method. A recent study indicates that this system with auxiliary equipment will be able to supply glass scrap on a competitive basis within a limited distance from the waste supply.[32]

Disposal

To obtain an estimate of waste glass, the unit data from Table 39 should be converted to weight, although volume is more significant. The following bases can be used to establish a weight range: (1) a 1969 report predicted that the average glass container weight in 1970 was about 78 lbs per gross, or 0.54 lb per unit;[35] (2) Owens-Illinois reported that in 1971 their collection centers recovered 272 million containers weighing 138 million pounds, which is an average weight of 0.51 lb per unit.[36] Thus, the 38.2 billion units cited in Table 39 represents about 19 to 21 billion pounds (or 10 million tons) of glass. Considering that almost 90 percent of the glass in municipal waste is in the form of discarded,[37] therefore, the total of all waste glass is 11 million tons. This figure compares well with the 12 to 15 million tons of waste glass often cited in the literature.

SELECTION OF SOLID WASTE REDUCTION OPPORTUNITIES

There are only a few products which the Government purchases which are made wholly or partly of glass. On the basis of selection criteria B-1, B-2, and B-3 (Table 8), glass containers are by far the major opportunity area because they are a significant and usable component in the solid waste stream. Similarly, according to criteria A-1, A-2, and A-3 (Table 8), glass containers are an opportunity because they account for a significant percentage of the domestic output, and almost everyone purchases them.

However, generally the Government does not specify the type of glass container used in packaging the products purchased by it. Typical examples in this category are many subsistence items that are purchased "off the shelf," or as level "C" packaging (see Section I). The selection of the type of glass container is usually left to the supplier.

After reviewing most of the specifications for glass products, we found that none stated that secondary materials may or may not be used, with one exception. Recently, one of the Federal specifications for thermal insulation was modified so that secondary glass could be used. This product is being manufactured commercially by at least one company who uses up to 50 percent waste container glass.[38]

New Application Opportunities

Many longer-term opportunities are also developing for the use of waste (or secondary) glass in new products that do not involve recycling in the conventional sense. In these applications, the spent product is not remelted, and the final product is one that has a long service life. The following are some examples.

1. Crushed waste glass has been used to replace aggregate in asphalt-base road paving material in at least 15 test sites. This material is known as "Glasphalt," and was developed by Dr. Ward Malisch at the University of Missouri. Impurities are easily tolerated by this process, but for this concept to be practical, waste glass must be available in reasonably large and dependable quantities and competitive in price with normal aggregate.[39]

2. Waste glass also has been used for wall panels, tiles, and building blocks. The wall panels, containing from 13 to 94 percent glass, were developed by the Colorado School of Mines Research Institute. Products with the high glass content take on a marble-like finish.[40]

3. Waste glass together with a polymerizable monomer as binder also has been used to produce a composite that can be used for fabricating sewer

pipe that is potentially competitive with concrete pipe. Typically, about 10 percent monomer is used with 90 percent waste glass. This product has been developed by Brookhaven Laboratories.[41]

The technical and economic viability of these new products utilizing solid waste is presently being evaluated. All are at the development stage, and specifications for them have not been written. However, the Federal Government can play an important role as these products are developed by specifying and purchasing them, if they can meet the needs technically and economically.

Packaging Materials

Recognizing that glass packaging is an important solid waste reduction opportunity area, the question again arises "What should the Federal Government specify?" One strategy that is consistent with the objectives of this study is to specify the use of the lightest-weight containers that are commercially available. The packaging industry is always striving to develop new technology in this area.[42] For example, Glass Container Corporation (Fullerton, California) has developed a glass coating that imparts excellent toughness that allows bottle makers to use thinner walls (this is now commercial). On the other hand, Owens-Illinois, Inc., expects to have a plastic-glass composite bottle in commercial production in 1973. The glass part of the package is very light, weighing only about three ounces, and the glass walls are thin. This composite container, if separated, could be used in glass container manufacturing, because the plastic would be burned off in the glass furnace.

Still another approach might be to specify the use of secondary material in the container. This strategy must take into account the supply and demand for the secondary material, various technical factors, and the structure of the industry.

The glass beverage container is available as a returnable or a one-way container. Thus, as another strategy the Government could specify the use of returnable beverage bottles. The case of the returnable vs. the one-way bottle is a continuing issue, and thus this alternative is an important one. (See EPA-R2-72-059, The Beverage Container Problem: Analysis and Recommendations.)

In the section that follows, we explore each of these alternatives and its impact on the economy and the generation of solid wastes. First, let us consider the future of the glass container in the absence of any change in Government procurement policy.

GLASS CONTAINERS - BASELINE FORECAST

Domestic consumption of glass containers has increased from 195.9 million gross in 1965, to 265.4 million gross in 1970--an average annual growth rate of 7 percent.[43] Virtually all of this growth can be attributed to the emergence of non-returnable beer and beverage bottles. Food containers, including dairy, increased from 76.6 million gross to 83.3 million gross during the same period--an average annual growth rate of about 2 percent. Consumption of containers for products other than food and beverages has declined from about 9.1 billion units in 1966, to 8.5 billion in 1970. Consumption of returnable beverage and beer bottles has been decreasing, and we expect that this trend will continue.

To project growth of the industry beyond 1975 with any degree of confidence is difficult. Excluding ecological influences, we expect that consumption of food containers will continue to grow at an annual rate of 2 percent. However, the growth rate of the non-returnable soft-drink and beer bottles is not expected to match the 1965 to 1970 period, when consumption increased from 38.6 to 108.2 million gross, an annual average growth rate of about 35 percent. Factors which will tend to decrease the growth rate, particularly in the 1975 to 1985 period are:

1. The decreasing market for the returnable bottle, from which much of the growth of the non-returnable has come.

2. Increasing concern and possible legislation over the safety of glass containers for beverages and beer.

3. Increasing competition from metal and plastic containers. Two important factors contributing to this competition are:

    a. Although present competitive containers are more expensive to manufacture, they are also significantly lighter. Weight is significant because shipping costs of both empty and filled containers are rising, as the trend toward serving larger areas from a single plant continues.

    b. The FTC has announced a suit against seven major soft-drink bottlers concerning the legality of the geographic franchise system. Elimination of this system would accelerate the trend toward consolidation, and relatively fewer such bottlers would remain in existence. Such consolidation would favor lightweight, unbreakable, high-filling-speed containers.

We estimate that the consumption of glass containers will increase from 38 billion units in 1970 to about 46 billion in 1985 (Table 40). Our projections are considerably more pessimistic than most other published estimates. We believe the more optimistic projections over-emphasize past growth trends for glass containers, and under-estimate the current trend to metal cans and plastic containers for soft drinks and beer.

Today, other trends in the glass industry that are likely to reduce the glass portion of solid waste in the 1970-1985 period include:

1. the shift to lighter glass containers, and
2. industry and Government efforts to increase the recycling of scrap glass.

THE GLASS CONTAINER--IMPACT OF ALTERNATIVE RECOMMENDATIONS

Specification of Lightweight Glass Containers

The glass container industry has been very active in its effort to reduce the weight of glass containers without sacrificing safety or causing breakage at the bottling plant. The Glass Manufacturers Institute sets minimum glass-bottle weights for a number of types of glass containers, and this information can be used by the Government in drawing up specifications. Thus, where Government purchases of products are in glass containers, the Government can specify that the glass containers should be the minimum weight commercially available. The newer, lightweight bottles, which are in the early stages of commercialization, can be specified as they become available.

An announcement that the Government is to specify lightweight containers should encourage public demand for the new glass containers, which could initiate a "ripple" effect. In this way, the recommended specification change might spur a desirable change that is already occurring.

This specification change, although it will tend to reduce the tonnage of glass container production, will have a minimal disruptive effect on the glass container industry and will effectively reduce the glass fraction of solid wastes. Therefore, we recommend this change.

TABLE 40

ESTIMATED CONSUMPTION OF GLASS CONTAINERS (1970-1985)
(Billion of Units)

Product Packaged	1970	1978	1985
Food	12.1	13.0	14.0
Soft drink and beer	17.6	23.0	26.0
All other	8.5	7.0	6.0
Total	38.2	43.0	46.0

Source: Arthur D. Little, Inc.

Specification of Returnable Bottles for Beverages

Banning one-way glass containers, or requiring a deposit to encourage their return, are strategies presently being discussed in private and Government circles as an effective way to reduce glass waste. This approach can theoretically reduce the beverage container glass wastes as much as 90 percent (on a unit basis), considering that one returnable bottle can replace about eight to ten one-way bottles. As we have indicated, glass wastes from beverage bottles (beer and soft drinks) represents about 40 percent (on a unit basis) of all glass-container wastes. Therefore, this approach could have a significant impact on reducing the generation of solid wastes.

On the other hand, U.S. consumers and the distributors of beverages have been accustomed to the convenience of the one-way bottle. The glass container industry is obviously interested in the one-way container because the manufacturers would be severely affected by a changeover to returnables. According to a recent study, a nationwide ban on one-way bottles would reduce the GNP by more than $10 billion and eliminate more than 164,000 jobs.[illegible] All of these factors are impediments that could reduce any "ripple" effect, even if the Government specified the use of returnable bottles.

The purchase of beverages by the Federal Government (and only a portion is packaged in glass) was only about 0.1 percent of all beverage production in 1970. Most of the purchases were for commissaries, where--given a choice--customers have continuously sought the convenience of one-way bottles. Considering the small quantities purchased by the Government, the impact of Government action will have a minimal impact on the solid waste stream. Therefore, we do not recommend that the Government specify only returnable bottles. The Government should let individual procurement officers choose the container type each needs.

Specification of Secondary Content

As noted above, there is a market for clean glass container scrap at the glass plant--the industry today has a goal of 30 percent cullet in batch furnace charges. Presently, only about 2 percent of discarded glass containers are being recovered from the solid waste stream for this application. Until the technology for separating glass from mixed solid waste becomes widespread, specification of a secondary glass content higher than the present 15 percent average would require an increase in container cost, which would have to be borne by the Government, and considering the questionable benefits in terms of solid waste reduction, the costs would be difficult to justify. Significantly, these higher costs would make glass containers non-competitive with alternate container materials.

If, despite this, the Federal Government still requests glass containers with a high cullet content, a given container plant would have difficulty manufacturing such a small volume, even if the Government were willing to pay the price. Production of containers for the Government on a separate bottle line would involve additional costs to the container manufacturer for transportation, raw materials, and storage, and would create a significant logistics problem. The net effect of a specification for a relatively high (higher than 15 percent) cullet content in glass containers would mean that container manufacturers would not bid on a Government purchase. Therefore, we do not recommend this approach.

V. RUBBER

AN OVERVIEW

Structure of the Industry

The rubber industry consists of two major segments--synthetic rubber producers and fabricated rubber product manufacturers or fabricators. The rubber producers provide the raw materials; the fabricators combine rubber or elastomeric materials with fabrics, metal products, chemicals and mineral fillers, and by suitable processing produce thousands of different products.

Most synthetic rubber produced in the U.S. is made by divisions of the major rubber product manufacturers. The remaining production is divided among oil and chemical companies. As a result, an estimated two-thirds of the general purpose synthetic rubbers is marketed either as interplant transfers or as sales to affiliated companies.

A total of 23 companies produce synthetic rubbers in the United States, and 18 are producers of the most important synthetic rubber--styrene butadiene rubber (SBR). The four largest rubber companies--Goodyear, Firestone, Goodrich, and Uniroyal--account for about half of all synthetic rubber capacity. The largest producer, Goodyear Tire & Rubber, has a capacity of about 18 percent of the total industry. Firestone Tire & Rubber ranks second.

The fabricated rubber products industry consists of about 1,500 companies, but most are specialty shops employing 10 people or less. This industry is concentrated in the North Atlantic and East North Central states, plus Alabama, Texas, and California.

The major fabricated rubber product is tires. Tires and tire products account for about 65 percent of all fabricated rubber products. About 180 manufacturers in the United States, employing about 100,000 people, produce tires and tire products with annual sales of $5.2 billion.[65] The four largest rubber producers account for about 70 percent of the shipments of all tires and tire products.

Two smaller segments of the rubber industry convert used or rejected rubber products into reusable materials. One segment is responsible for reclaiming or recycling rubber, and the other, for retreading tires. The reclaimers primarily convert scrap tires to a workable state, much of which is blended back into tire compounds for manufacturing new tires. This segment consists of 14 companies operating 20 facilities that employ about 1,800 people.[46] The retreaders, on the other hand, convert worn tires to a reusable form by applying new tread compound. Of the 8,500 retread plants in the U.S., 8,000 are small independent companies and the others are operated by the large tire companies and other mass-marketing organizations.[47]

Rubber Consumption and Use

Synthetic rubber was developed during World War II; earlier, natural rubber imported from Southeast Asia was the sole general purpose elastomer. Today, synthetic rubbers dominate the market. About 2.1 million long tons of new rubber were consumed during 1971, compared to 0.6 million long tons of natural rubber, which represents about 20 percent of the total new rubber consumption (Table 41). In 1971, only 195,000 long tons of reclaimed rubber were used. The new rubber was converted to about 6.8 million long tons (15 billion pounds) of rubber products, calculated on the basis that about 40 percent of the average fabricated rubber product is rubber (the remainder consists of oil, carbon black, and additives).

Assuming growth rates of 4.5 percent for natural rubber and 7 percent for synthetic rubber, then the total consumption of natural, synthetic, and reclaimed rubber is expected to rise from about 3 million long tons (1971) to about 4 million in 1978 (Table 41). Note that the annual tonnage of reclaimed rubber to be consumed during this period is expected to remain constant and, as a percentage of all rubber consumed, reclaimed rubber is expected to drop from 6.8 to 5 percent.

As has been true for many years, SBR is by far the most important rubber used in the United States. In 1971, it accounted for 54 percent of all synthetic rubber consumed (Table 42). Natural rubber and polybutadiene are the other important rubbers; these and SBR are the major rubbers used in the manufacture of tires. The three rubbers are also the major ones available as reclaimed rubber. Each of the other synthetic rubbers listed in Table 42 account for only a small portion of the market.

Although hundreds of individual products are made of rubber, the end-use pattern for rubber can be divided into a few significant broad categories (Table 43). The major use for both new and reclaimed rubber is in tires and tire products. The mechanical goods market is a far second category and accounts for only about 16 percent of new rubber and 12 percent of the reclaimed.

TABLE 41

ESTIMATED CONSUMPTION OF NEW AND RECLAIMED RUBBER

(Thousands of Long Tons) †

	1970	1971	1975	1978
Natural rubber	559	602	670	730
Synthetic rubber	1917	2079	2440	2970
Total	2476	2681	3110	3700
Reclaimed rubber	199	195	199	199
Total	2675	2876	3309	3899

Source: U.S. Department of Commerce and Arthur D. Little, Inc., estimates for 1975 and 1978

† One long ton = 2240 lbs

TABLE 42

CONSUMPTION OF NEW RUBBER IN THE U.S.
(Thousands of Long Tons)

	1970	1971	1972
Styrene-butadiene	1,120.0	1,415.0	1,405.0
Butyl rubber	90.0	97.0	100.0
Neoprene	150.0	160.0	170.0
Nitrile	60.0	65.0	68.0
Urethane rubber†	8.0	8.5	9.0
Silicone	9.0	9.5	9.8
Acrylic	5.5	6.0	6.5
Polybutadiene	275.0	290.0	300.0
Ethylene-propylene	52.0	50.0	53.0
Polyisoprene	92.0	95.0	100.0
Polysulfide	8.0	8.5	8.7
Natural	540.0	600.0	620.0
Total	2,409.5	2,700.0	2,850.0

Source: Rubber Age, January 1972

† Elastomeric, not including foam

TABLE 43

MAJOR END-USE MARKETS FOR RUBBER (1971)

	New rubber		Reclaim	
	Percent	Tons†	Percent	Tons†
Tires and tire products	66	1,782	67.4	131.4
Wire and cable	1	27	-	
Foams	3.5	94.5	-	
Footwear	6	162.0	1.0	2.0
Mechanical goods	16.5	445.5	5.9	11.5
Other	7	190	25.7	50.1
Total	100.0	2,701.0	100.0	195.0

Source: Rubber Age, January 1972

† Thousands of long tons

Reclaimed Rubber

Reclaimers use two types of raw materials--discarded consumer wastes and scrap from the rubber products industry. The consumer-type wastes are primarily road-worn tires and used inner tubes. The scrap from manufacturers includes defective items, selvage, cleanouts, etc. Consumer wastes account for about 85 percent of the reclaimer's feed stock, according to Uniroyal.[46] Few of the specialty rubbers are marketed as reclaim. These rubbers are usually reclaimed on consignment for the company supplying the scrap. Thus, reclaim is primarily available as tire rubber in the form of SBR, natural rubber, and polybutadiene.

Reclaiming is a relatively complicated process. First, the rubber is separated from other materials in the rubber product, such as glass fiber, steel, and textiles. Then the rubber waste is reduced in size to about -30 mesh or smaller, and cleaned. After cleaning, the fine ground rubber crumb is devulcanized. Most reclaimers use a digester or wet process, where the rubber scrap is placed in a vessel and agitated with water and reclaiming oils, heated for a specified time, and then discharged as a slurry into a blow-down tank, where it is de-watered and dried. The reclaimed rubber is mixed or compounded with oils, fillers, and other additives and shipped in the form of slabs or in bales.

Despite the increasing production and use of rubber products in the United States, the consumption of reclaimed rubber has been declining. As a percent of all new rubber produced, reclaim has declined from 19 percent in 1958 to 10 percent in 1968. About 70 percent of the reclaimed rubber produced is used for tire and tire products and, presently the average concentration of reclaimed rubber in all tires is approximately 7-1/2 percent (most of this is post-consumer waste), which is equivalent to 260 million pounds per year. The amount of reclaim in different tires varies from zero to 25 percent. The higher concentration levels are usually used in the cheaper grade tires.

Traditionally, one of the main advantages of reclaimed rubber has been its lower cost. However, this is no longer true because of the present low-priced oil-extended synthetic rubbers. Today, the price of whole-tire reclaimed rubber with a 45 to 50 percent oil content is 10 to 12 cents per pound; a compounded tire rubber stock containing oil-extended SBR is approximately the same.

The advantage of using reclaim are: (1) lower processing costs (uses less electricity and time); (2) improved processing, because reclaim has less "nerve" or "stiffness"; (3) uniform cure in fast, high-temperature cycles.

The disadvantages are: (1) reduced strength--at the 20 percent additional level, tensile strength and elongation are reduced by about 10 percent; (2) poor abrasion resistance; (3) poor uniformity. Uniformity has been a continuous concern, and has been a major impediment to the more extensive use of reclaim.

Tires

Tires and tire products have two basic markets--original equipment (OE) and replacement. The OE tires are sold to the automobile manufacturers who play a leading role in tire design, because these manufacturers can modify the performance and suspension systems of new automobiles. On the other hand, replacement tires are sold to automobile owners.

The OE market fluctuates with automotive vehicle production. In 1970 only 37.6 million tires were shipped to the automobile manufacturers, but in 1965 shipments were 51.4 million units, and in 1971, 48.6 million units were sold (Table 44). The growth in replacement tire output has been faster than the related growth in motor vehicle registrations because of more frequent replacement and wider use of special tires such as snow tires. The replacement market for automobiles has grown from 94.9 million units in 1965 to 135.0 million units in 1971.

Trucks and bus tires represent a smaller market. In 1971, OE tires in this market amounted to 10.3 million units (includes 3 million tires for mobile homes), and replacement tires were 18.1 million (Table 44).

Construction - During the last few years and through the 1970's, the construction of tires has changed radically. The bias tire has been gradually replaced by the belted-bias tire and the belted bias tire will be gradually replaced by radial tires (Figure 9).

For many years tire manufacturers have used layers of rubber-coated fabric (plies) to form the body of their tires, called carcass or casing. The textile cords of the fabric in these plies were placed at an angle of about 35 degrees from the car's line of travel. The direction of this bias was alternated with each ply to provide stability in steering and resistance to punctures.

In radial construction, the cord in the fabric runs across the tire at 90 degrees to the line of travel. Next to these plies, under the tread, is placed a belt of two or more layers of fabric running only a few degrees off the line of travel. The belt makes for easier rolling, provides more puncture resistance, and increases tread wear by reducing friction and tread squirm.

TABLE 44

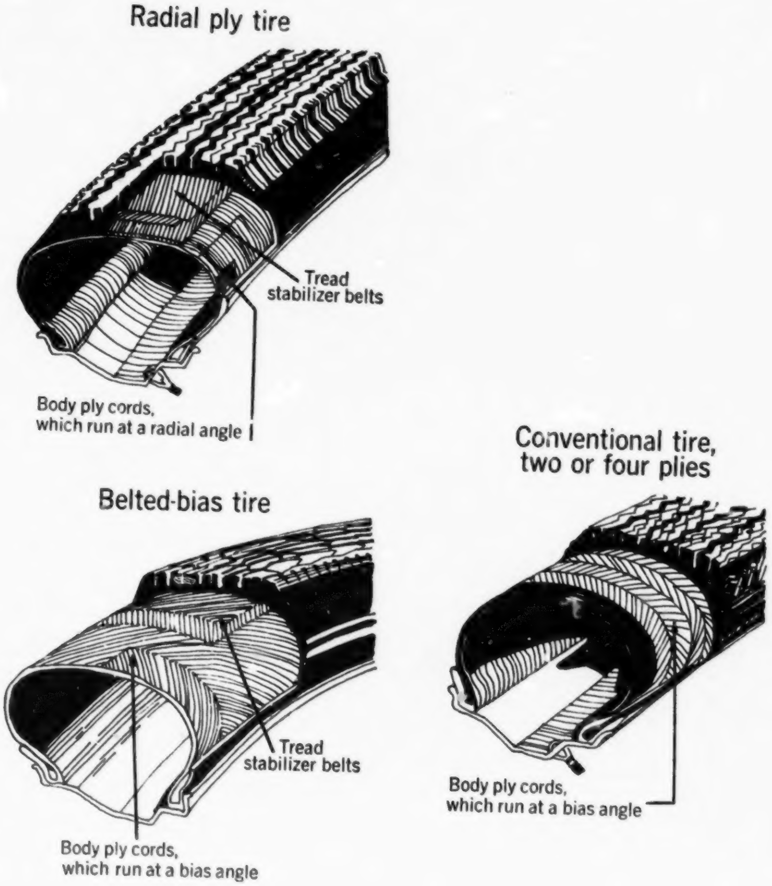
TOTAL TIRE SHIPMENTS
(MM Units)

Year	Passenger car		Truck and bus	
	O.E.	Replacement	O.E.	Replacement
1965	51.4	94.9	6.9	12.8
1966	47.4	101.8	7.4	14.6
1967	40.8	108.5	6.9	14.4
1968	49.9	121.1	8.5	16.3
1969	46.2	129.3	9.5	17.3
1970	37.6	129.6	8.6	16.7
1971	48.6	135.0	10.3†	18.1
1972‡	51.2	136.0	10.4	18.3

Source: Rubber Manufacturers Association

† Includes 3 million tires for mobile homes

‡ Arthur D. Little, Inc., estimates


Radial ply tire
Tread stabilizer belts
Body ply cords, which run at a radial angle
Conventional tire, two or four plies
Belted-bias tire
Tread stabilizer belts
Body ply cords, which run at a bias angle
Body ply cords, which run at a bias angle

The conventional tire has biased plies running at angles to the direction of travel; the radial tire has belts and the plies are at a 90 degree angle to the direction of travel; and the belted-bias is a combination of biased plies and belts.

FIGURE 9. TIRE CONSTRUCTIONS

Radial tires run only about half as hot as traditional tires, and there is considerably less tread squirm, which results in longer tire life. In addition, radials hold the road better because a greater part of the tread is in contact with the road. This permits faster stops and even increases gas mileage.

But despite these advantages, the tire industry has been slow to manufacture radials because suspension and steering systems on American-built cars are not engineered to radial tires. Radials mean louder, harder riding at slow to moderate speeds. Also radials cannot be produced on standard tire-making equipment and require costly retooling.

In 1967, Goodyear combined features of the bias ply and radial ply to produce the bias-belted tire. In this version, a belt, similar to the radial tire's belt, runs over the old bias plies. The bias belted tires provide many of the advantages of radials without many of their problems.

According to the tire companies, if tire life of the bias tire is rated at 100, the belted bias is about 150, and radials about 200 to 220. Thus tire life is essentially doubled with the radial. However, we expect that actual driving conditions will modify these wear factors. Stop and go driving, for example, generally does not show belted tires to the same advantage as does test-track driving at high speeds. At the present time, the cost per mile for each of these tires is about the same.

Retread Tires - In 1971, retread tires accounted for about 22 percent of the total number of replacement passenger car tires, compared to 28 percent in 1965. In the same time period, retread truck and bus tires only dropped from 37 to 36 percent of the market. Thus, each year, retread passenger car tires have accounted for a smaller portion of the market, while those for trucks and buses have retained a relatively constant share.

The retreader typically purchases discarded tires left with the major tire retailers by their customers. These used tires are first sorted. In this selection of a retreadable casing, usually 50 to 75 percent of the casings are rejected for defects. The selected casing is then placed on a buffing machine that grinds off the remaining old tread, leaving the casing the exact size and contour to fit a specific matrix or mold. The tire is then built up by applying a bonding cement and tread rubber. Finally, the finished tire is cured by heat and pressure, and the new tread is vulcanized to the casing. Depending upon the rubber compound used in the tread, the service life of the tire often can be doubled, and the cost of the tire on a per-mile basis is usually about one-half that of a new tire.

Normally, passenger car retreads are purchased by consumers either directly from the retreader (about 50 percent), or from tire dealers, service statons, and other retailers. In contrast, few retread truck and bus tires are available on the retail market because the owners of such tires bring them directly to the retreader and reuse the same tires on their own vehicles. At the present time, GSA retreads only their own tires; they do not purchase merchant retreads. In 1971, according to GSA, approximately 251,000 tires were retreaded in this manner by GSA (Property Management and Disposal Division), including off-the-road, truck, and passenger car tires. These purchases amounted to 0.5 percent of the total domestic consumption that year.

According to the Retreaders Association, most types of tires can be retreaded. Though the glass-fiber belted-bias tires have been extremely difficult to retread, retreaders believe radials will probably be easier because the casings are built for high performance. Today, the radial tire is being retreaded in European countries, where radials have been available for many years.

Safety Standards - Under a recent act of Congress (National Traffic and Motor Vehicle Safety Act of 1966), the Department of Transportation (DOT) has set safety standards for all tires--MVSS109 applies to new tires, and MVSS117, to retread tires. These standards specify that a certain proportion of a given size and design tire shall undergo qualification tests certified by the manufacturer. A proportion of production then has to be recertified at specified intervals. The essential requirements of the standard for new tires are:

1. The tires shall meet certain minimum uniformity and balance requirements.

2. The tire shall withstand a puncture test.

3. Dimensions shall be within certain tolerances.

4. Wheel tests shall be conducted for resistance to failure at normal speeds (50 miles per hour) in an overloaded condition, and at higher than normal speed under normal load.

For retreaded tires, the high-speed test is omitted, and the wheel test has been contested in the courts.

The Government specifications incorporate these same DOT standards. Furthermore, tire manufacturers who sell their tires to the Government must have their tires qualified by the designated tests, and the tires must be listed or approved for listing on the applicable Qualified Products List (QPL). In the case of retread tires, the QPL is not required, but at the present time these tires must pass the same wheel tests specified for the new tires (MVSS109) because the retreaders, backed by Firestone, have filed a suit against DOT to retract the standard MVSS117 for qualifying retreads. While this case is in litigation, the Government does not require the MVSS117 standard.*

Disposal

Rubber product waste amounts to more than 10 billion pounds per year, of which 6 billion pounds consists of scrap tires and tubes.[48] Most tire wastes consist of whole discarded tires from passenger cars, buses, and trucks. At the present time, more than half of all used tires are discarded.

The durability of synthetic and natural rubber which makes them suitable for tires in the first place, makes the problem of scrap tire disposal very difficult. They are not bio-degradable; they will exist virtually unchanged indefinitely, under a variety of environmental conditions. Most municipalities have banned open burning, and this once-popular method of disposing of scrap tires has all but disappeared. Landfill is probably the most prevalent way to dispose of scrap tires today, but it will become less convenient in the future. Land is becoming scarce, and already some land fill sites will not accept tires because discarded tires are bulky and not easily compacted.

SELECTION OF SOLID WASTE REDUCTION OPPORTUNITIES

Selected specifications of rubber products purchased by the Government representative of each end-use market were first reviewed, and specifications were screened to determine whether reclaimed rubber could be added to the rubber stock to fabricate the rubber-containing product.

Minimum Opportunity Areas for Solid Waste Reduction

The following products were not recognized as solid waste reductio opportunities, because they cannot readily use reclaimed rubber.

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*Effective June 1, 1973, the wheel test under MVSS117 is no longer required.

1. Adhesives - Government specifications for adhesives include material and performance requirements, and many are specialty high-performance products. Although some commodity-type adhesives use reclaimed rubber, virgin natural rubber is required in most of these applications, because it provides "quick grab." No satisfactory direct replacement has been found.

   Furthermore, where oil and gas resistance is needed, polychloroprene (Neoprene) or nitrile rubbers are required, because of their inherent chemical resistance. These rubbers are not readily available in reclaim form. Therefore, we believe that little can be gained by rewriting most of the adhesive specifications to include reclaim, because an extensive research program would be required, and the benefits in terms of solid waste reduction would be minimal.

2. Gloves and Gaskets - Gloves and gasket materials generally require special properties that are not easily achievable with reclaim. For example, many types of gloves must be oil resistant and must meet stringent electrical and non-slip requirements.

3. Hose Assemblies - In many cases these products have the same stringent requirements as gloves and will not tolerate the use of general-purpose reclaimed rubber.

4. Matting and Mattresses - Theoretically, matting and mattresses could tolerate a certain amount of reclaimed rubber; however, over the years the general trend has been to substitute urethane foams for synthetic rubber in mattresses. Therefore, today, the market for reclaimed rubber in this application is extremely small and is expected to shrink further.

5. Special Rubber Compounds - The Government specifies rubber compounds for certain applications. The properties dictate the specific formulation. For example, very often these compounds must be sunlight-, oil- and ozone-resistant--properties that make the use of reclaim impractical.

6. Rubber Sheets - Rubber sheets similarly must meet stringent specifications such as those cited above. Therefore, the use of reclaim is seldom appropriate.

7. Rubber Wire Insulation - Little reclaim is used in wire insulation. Most specifications for rubber wire insulation have stringent electrical and aging requirements. Therefore, the wire manufacturers have hesitated to use reclaim stock. Furthermore, most wire coating is Neoprene, because it has superior abrasion, sunlight, and ozone resistance. But, as noted above, reclaimed Neoprene is not available in appreciable quantities.

8. Windshield Wipers and Windshield Systems - Windshield wipers or windshield gasketing systems require good outdoor weathering characteristics. Wipers require the use of very special rubber compounds so that the blade wipes cleanly. Specifications for gasketing systems dictate that the caulking compounds be polysulfide or butyl rubbers, or a similar elastomeric material with good aging and weathering characteristics, and reclaimed rubber generally does not meet these requirements.

Potential Solid Waste Reduction Opportunities

Road Building. Reclaimed or reused rubber may be useful in secondary applications such as road building. Several states now have specifications calling for adding virgin rubber to asphalt to improve its characteristics but, according to the reclaimers, reclaimed rubber can be used interchangeably in this application. In another application, chopped rubber is used as a roadbed aggregate or as an interface between the surface and the roadbed, where it has been reported to improve road quality.[48]

The Rubber Reclaimers Association has shown that the use of reclaimed rubber in asphalt roads improves the temperature stability of the asphalt, skid resistance, and wear characteristics.[49] If as little as 5 percent rubber is incorporated in all new asphalt used in road building or road repair in the U.S., then the entire annual output of scrap tires could be used.[50]

Interestingly, a recent study has indicated that a mixture of asphalt and rubber (1/8-inch ground tire scrap) laid as a film between an old road surface and a new one can improve the durability of road repairs and also can potentially improve new road construction. A preliminary estimate indicates that the annual output of scrap tires would furnish enough rubber to apply this process to approximately 30,000 of the 200,000 miles of resurfacing performed annually in the U.S.[51]

These applications for used or reclaimed rubber are very attractive solid waste reduction opportunities. Like other construction applications, they remove troublesome solid waste by "burying" it for an extended time. Although expenditures by the Federal Government for road surfaces serving its own needs are small, the Federal Government has significant leverage in its use of indirect purchasing. In this case, the specifications are written by the Federal Government, but the roads are built by state and local governments with Federal subsidies; therefore this application is a good opportunity area for reducing solid waste.

In spite of the claims mentioned above, research is needed to determine the most effective way of using scrap tires to achieve optimum results, considering that asphalt and aggregate vary in different sections of the country, and the climactic conditions and requirements also vary. We recommend that research studies under Government sponsorship and in cooperation with industry should be undertaken to define the most effective way of utilizing used or reclaimed rubber, especially ground old tires, in road building applications. The use of ground old tires is most desirable.

Once the product has been defined, then the Federal Government should specify used or reclaimed rubber as an aggregate or as a new surfacing material for the roads built by federal, state, and local governments.

Tires - The most significant solid waste reduction opportunity area is tires. Not only are tires the major rubber product, but they are also the major rubber waste and are very troublesome in the disposal area because they are bulky and difficult to compact or incinerate.

Potentially, the specifications for tires can be changed in a number of ways. For example, a most effective way of reducing solid waste is to specify the use of a product with a long service life, if it is available. Thus, based on the discussion in the previous section, the Government should purchase primarily radial tires as original equipment and, whenever possible, as replacement tires. This approach can extend the service life of the normal bias tire by a factor of two, and thus reduce the generation of solid waste by the Government by about one half. Government purchase of retreaded tires can similarly extend the tire's service life. However, the Government only purchases about 1.5 percent of the domestic output of replacement tires and 1.7 percent of the domestic output of OE tires in their purchase of motor vehicles.

As another approach, the Government could specify that all tires it purchases contain a certain percentage of reclaimed rubber or, alternatively, the Government could require that companies bidding for tire contracts would have to certify that they use a certain percentage of reclaimed stock in their total tire production.

In the section that follows, we will examine these alternatives for specifying and purchasing tires, as they affect the reduction of solid wastes and the economics of the related industries.

TIRES - BASELINE FORECAST

Today, the rubber industry agrees that the radial tire is the tire of the future. The question is - how soon? M. G. O'Neil, President of General Tire, contends that the auto industry plans to equip all U.S.-made vehicles with radials by the mid-70's, and Patrick Ross, President of Goodrich, also predicts that in 1976 two out of every three models out of Detroit will come equipped with radial tires. Goodyear is considerably more conservative and expects the radial tire to penetrate the market by only 15 to 18 percent by 1976.

Among the automobile companies, Ford Motor Company is leading the move toward radial tires. In 1972 Continental Mark IV and Thunderbird models have steel-belted radials as standard equipment and such tires are optional on 1972 Mavericks, Pintos and Comets. They will also be made optional on Ford Mercury models before the 1972 model year is over.[52]

We are optimistic and forecast that radial tires will account for about 70 percent of all OE passenger car tires sold in 1976; this percentage could rise to as high as 90 percent by 1980 (Table 45A). Truck and bus tires are another matter, and the bias tire will still be the major truck and bus tire throughout the decade of the 70's (Table 45B). The introduction of radial tires will primarily displace the belted bias tires during the decade of the 70's.

The radial tire is not expected to penetrate the replacement tire market to a major extent (Table 45C); by 1976 we expect that the

TABLE 45

FORECAST OF TIRE SALES BY TYPE

A. O.E. Passenger Car Tires

	1970	1971	1972	1973	1974	1975	1976	1978	1980
% Belted Bias	86.8	85	84	76	68	40	20	10	-
% Radial	0.3	0.5	2	10	20	50	70	80	90
% Bias	12.9	14.5	14	14	12	10	10	10	10

B. Truck and Bus Tires

	1970	1971	1972	1973	1974	1975	1976	1978	1980
% Bias	97	96	94	91	88	85	82	78	63
% Belted Bias	-	1	2	3	4	5	6	10	12
% Radial	3	3	4	6	8	10	12	22	25

C. Passenger Car Replacement Tires

	1970	1971	1972	1973	1974	1975	1976	1978	1980
% Belted Bias	31	36	38	41	43	43	40	35	10
% Radial	3.5	5	7	9	12	15	20	35	50
% Bias	65.5	59	55	50	45	42	40	40	40

Source: Arthur D. Little, Inc.

radial tire will control about 20 percent of the passenger-car replacement tire market. More extensive penetration could occur by 1980, if the costs of the replacement tire are reduced. Today, radial tires are very expensive--about 50 to 80 dollars per tire. However, we expect that the price of radials will drop eventually, so that it will be perhaps 40 to 50 percent more costly than bias tires.

Because of the steady improvement in tire mileage during the 1972 to 1980 period, we expect a slower growth of the market for replacement tires (about 2.5 percent), as compared to the growth of the market for OE tires (about 3.5 percent). We estimate that the total consumption of OE tires for passenger cars, trucks, and buses will grow from 61.6 million units in 1972 to 81.4 million units in 1980 (Table 46). During this same period, the number of replacement tires will grow from 154.3 to 192.1 million units.

In making these estimates, we considered the longer wear of the belted bias and radial tires that we expect will have a major share of the market during the 1970's. According to our analysis, the sale of each million belted bias tires in any one year results in the reduction of the replacement market two years later by approximately 200,000 tires, compared with what would have been experienced had bias tires been sold. Similarly, the sale of each million radial tires sold in any one year will result in the reduction of the replacement market two years later by 330,000 tires, compared with what would have been experienced had only bias tires been sold. However, these estimates are relatively conservative and could possibly be doubled.

With the rapid development of the interstate highway system, intercity and interstate commerce has experienced an even faster rate of growth than passenger car traffic. As a result, the market for truck and bus tires is expected to grow at an even faster rate than passenger tires. Although truck and bus tires represent about 17 percent of the total tire shipments, they constitute a much larger proportion of the dollar volume.

Retread Tires

The retread tire market will continue to decline. We expect the passenger-car retread tire market to drop from 22 percent of the passenger car replacement tire market in 1972 to about 16 percent in 1978--a decline of about five million tires (Table 47). By 1980, this market could lose an additional 3 million tires. During this same period, retreaded truck and bus tires will increase slightly from 10.5 million units in 1972 to 12.1 million units

TABLE 46

ESTIMATED CONSUMPTION OF ORIGINAL EQUIPMENT TIRES (1972-1980)

Year	Passenger Car MM Units	Truck and Bus MM Units	Total MM Units
1972	51.2	10.4	61.6
1973	52.5	10.8	63.3
1974	54.5	11.4	65.9
1975	56.2	11.9	68.1
1976	58.3	12.5	70.8
1978	62.0	13.6	75.6
1980	66.6	14.8	81.4

Source: Arthur D. Little, Inc.

TABLE 47

ESTIMATED CONSUMPTION OF NEW AND RETREADED REPLACEMENT TIRES (1972-1980)

Year	Passenger Car (MM Units)		Truck and Bus (MM Units)		Total (MM Units)	
	New	Retreads	New	Retreads	New	Retreads
1972	136	38	18.3	10.5	154.3	48.5
1973	143	37	18.9	11.0	161.9	48.0
1974	149	36	19.4	11.3	168.4	47.3
1975	154	35	19.8	11.6	173.8	46.6
1976	159	35	20.2	12.0	179.2	47.0
1978	165	33	20.6	12.0	186.6	45.0
1980	171	30	21.1	12.1	192.1	42.1

Source: Arthur D. Little, Inc.

in 1978, although the percentage will remain essentially constant at 36 percent of the truck and bus replacement tire market (Table 47).

The decline in the use of passenger-car retread tires has been caused by a number of factors. For example, customer experience dating back before the retread industry reached its present level of sophistication has prejudiced much of the driving public that retreads are somehow inferior. The very word "retread" connotes inferior. However, the growth of the market for retreaded truck, bus and airplane tires tends to negate this thinking. Users of these tires look for service and low cost, and do not hesitate to retread tire casings more than once. Apparently, one of the reasons why retreaded truck tires are more easily accepted is because the truckers are careful that their tires are not completely worn before they are retreaded. The trucker usually has his own tires retreaded, instead of purchasing merchant retreaded tires.

Another factor responsible for the decline of retread tires is the introduction of the so-called "cheapies." These are third- and fourth-line new tires, specifically designed to compete in the retread tire market. These tires carry the namebrand of the national company and are backed by national advertising and distribution. The customer who wants to pay less for his tires usually purchases these cheaper new tires rather than retreads. Thus, the small retreader with his brandless tire cannot easily compete.

The present quality specifications for retreads further compounds the problem of the retreads. Because of the inherent variations in retread tires, these tires have greater difficulty in meeting the new DOT safety standards, not necessarily because the tires lack safety and quality, but according to many of the retreaders, the DOT test does not adequately represent a realistic test.

Reclaimed Rubber

Today, on the average, only about 7.5 percent of the rubber used in all tires is reclaim, as mentioned above; ten years ago the average was 12.5 percent. We expect the average to continue to decrease during this decade because the cost of reclaim rubber compound is almost equivalent to virgin SBR compound and, with the coming of the radial tire, the high performance demands will further limit the market for reclaim.

Reclaimed rubber has been used in various parts of the tire, but most of it is used in the sidewall and undertread. However, with the current demands made on the tires for high performance, which has resulted in an increase in the flexing and heat build-up of the rubber, the trend has been to substitute new rubber for reclaimed rubber. As compared to new rubber, reclaimed rubber compounds usually do not have sufficient resistance to flex cracking, and they have low abrasion resistance, which limits their use to very low levels in tread compounds. However, larger amounts of reclaim (up to 25 percent) are used in lower quality tires.

Just as retreads have a poor image, reclaim is often considered a cheap diluent. This public image has also led to the decline of this industry. Although reclaim can often be made technically equivalent to virgin rubber, the reclaimers today cannot justify any development work, because their industry has been squeezed by both high costs and low profits.

IMPACT OF ALTERNATE RECOMMENDATIONS--TIRES

Specification of Purchase of Radial Tires

The tire industry is poised to change over their production to the radial tire; therefore, even with a "ripple" effect, the Government purchase of radial tires could, at best, hope only to speed this change. The rate of change to radials is primarily limited by the speed with which the tire industry can convert its tire making equipment.

In the case of OE passenger car tires, which are purchased with the car, the Government's request for radials will easily be met by the auto makers. However, this purchase will induce only a minimal "ripple" effect, because the auto makers already stock a number of types of tires, including radials. Thus, the impact of this Government purchase on the tire and auto makers also will be minimal, because the Government purchases only about 1.5 percent of the total domestic output of tires and innertubes.

Similarly, the purchase of radial replacement tires will have a minimal impact on the industry. Nevertheless, we recommend that GSA specify the use of radial tires for OE and replacement applications, because this action will reduce the tire rubber wastes generated by the Government's purchases by approximately one half. Furthermore, public announcement of this specification change and purchase may influence institutional purchases of tires (hospitals, schools, merchants, manufacturers, etc.) and thereby achieve a limited "ripple" effect, especially in the passenger car replacement tire market.

Modification of the Specification for Retread Tires

Based on information obtained from tire manufacturers, retreaders, and some users of retreaded tires, when tires are retreaded following the procedure outlined by the Tire Retreading Institute (Tire Retreading Institute, National Standards for Treading Automobile and Truck Tires, as revised February 1972), they are safe, serviceable, and more economical than new tires. However, according to a report by the U.S. General Accounting Office (GAO),[53] "no adequate tests or studies have been made, and . . . available evidence was not sufficiently decisive to permit a conclusive judgment as to the reliability of rebuilt tires under all driving conditions." On the other hand, a member of the Property Management and Disposal Division of GSA claims that in their experience with retread tires, no more than 3 percent have been returned. This is good by any new tire manufacturer's standards.

The retreaders have recently requested the Government to reconsider the DOT standard for retreaded tires (MVSS117) because this standard requires a wheel test that does not correspond to actual use. Many of the retreaded tires cannot qualify, even though the retreaders believe them to be safe and are willing to provide the purchaser with a warranty similar to that provided with a new tire.

The National Traffic Safety Agency of the U.S. Department of Commerce claims that there is no reason to prohibit the use of retread tires for safety reasons, provided the tires are adequately inspected to assure that they are in safe condition prior to retreading and are retreaded by an acceptable procedure, such as proposed by the Tire Retreading Institute.[53]

Officials of the California Highway Patrol also advised GAO that when their retreaded tires were put through very strenuous tests, including speeds up to 150 miles per hour, oil slicks, spin-outs, and other road hazards, they observed no failures.[53]

Therefore, we recommend that the Government initiate a program to adequately test retread vs. OE tires to insure that they are indeed safe when subjected to the same driving conditions as OE tires. Also, the Government and industry should continue in their research to develop appropriate non-destructive tests such as infrared analysis to measure the adequacy of discarded casings before they are retreaded. Both DOT and the tire companies are currently working in this area.